FEILDEN'S MAGAZINE.

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Retrospect.

THE present month closes the first year of the Twentieth Century, and the consciousness of this fact naturally suggests a retrospect, in order to ascertain, if possible, what promise the past eleven months contain for an existence that is predestined to last a full hundred years. Baptized already, "The Century of Engineering," the lineal descendant of the Nineteenth Century is not likely to make, as so often do the children of man, its sponsors blush for the incongruity between the name it received in its infancy and its true character as revealed in the course of later experience. In fact, a review of its earliest days shows so clearly the new century's tendencies that there is little cause for anticipating disappointment. Especially as far as our country is concerned, have we good reason to be satisfied.

When this Magazine was started, the industrial conditions prevailing in Great Britain, as compared with those existing in the countries of our chief competitors, were such that it became incumbent upon those among us who knew the facts, to direct attention to the danger threatening us, as a manufacturing and exporting nation, from American and Continental rivals. Both of them, while rigidly excluding our products from their markets wherever such products might successfully compete with similar articles of home manufacture, were using every method available in their efforts to oust us also from the markets of other countries. Though, perhaps, vaguely aware of this attitude on the part of our competitors, our manufacturers had certainly not fully realised the seriousness of the case. Great Britain's paramount position in nearly all branches of industry had lasted without interruption for so long a period that the present generation had begun to consider it an inalienable possession handed down to them as an heirloom, never dreaming that its ownership might some day be disputed.

It was because this delusion would have to be met without further delay, that the founders of FEILDEN'S MAGAZINE were prompted to create an organ devoted, in a business sense, solely to British interests. For this purpose it was decided to refuse all advertisements from rivals of British industry, a step which our readers will grant was a *bonâ fide* sacrifice, but a necessary one if our aim was to be attained, namely to gain the confidence of the British manufacturer.

Our sacrifice has not been in vain, as has been proved by the swift recognition of the magazine as a protagonist of the British manufacturer, and its reception as a leading technical organ.

Even more gratifying, however, is the fact that British methods are really undergoing a transformation, and with the removal of the fiscal and labour disabilities that are at present tending to throttle our industries, we may again occupy our place in front of modern industrial progress. We do not claim the merit of having given the first impulse to this important change in the industrial life of this country, nor that we have acted alone in reiterating its necessity as the only possible way of regaining lost ground. We have had our share, however, in this work, and a mere glance at the 29 issues of FEILDEN'S MAGAZINE is sufficient to convince any unbiassed reader that we have been faithful in every point to our original programme. The vigorous campaign we are arranging for 1902 should add still further to the unique record of this periodical and to the material interests of its supporters.

The Battle of the Volts.

THE controversy in the recent inquiry before the arbitrator appointed by the Board of Trade on the electrification of the Metropolitan railways, will probably be known as the Battle of the Volts, but it might equally be called the Battle of the Continents, for it is with mixed feelings that the average Britisher must contemplate the struggle going on between the representatives of the American and European continents for the privilege of providing power to run trains in the heart of his capital city. It is not so long since the rivalry between the Continents was as to which should have the most and the best of British goods and British brains.

One cannot help wondering also if, in the natural course of development, the hitherto go-ahead Americans are now obliged to call a halt, and therefore resent the entrance into the field of a younger and aggressive rival.

And now as to the merits of the case. Why should we be limited to a pressure of 500 volts; and are we to be so limited for all time? Is it because the Board of Trade have limited the working pressure at that figure? Surely those who use this argument know that the Board of Trade exists to regulate, and not to rule, and that immediately it is shown that the 500-volt limit can be relaxed with safety to the public, the rule itself will go the way of other long-forgotten limitations. In view also of the fact that at no distant future the whole of the English railways will be converted to electric driving, it will become absolutely necessary to adopt higher voltages. It is more than probable that before long we shall wonder why we made such a fuss about a mere 3,000 volts. When Mr. Ferranti first made his bold suggestion for the Deptford station, many of us shook our heads. Yet Mr. Ferranti has killed fewer people with his 10,000-volt system than have been killed by the innocent 500-volt systems.

There are three main points to be considered in the controversy—the pressure, with its elements of danger; the question of naked overhead conductors, with that pressure between them; and the question of acceleration. There is also what, for the public, is the important but supplementary question of prime cost and running expenses.

With regard to the danger of the higher pressure, it may be taken as now clearly established that only very low pressures are absolutely safe—something like 100 volts or less. If you go above that pressure, just as if you go above other limiting pressures in, say, steam engineering, the question of safety is merely one of care in design and working. Practically the limit with electricity is fixed by the ability to insulate efficiently under the conditions of service. The matter of safety devices may be put into the same category. High pressure means small currents, and in the case of the polyphase system the current to be collected from each trolley wire is approximately $\frac{1}{15}$th that to be collected from the continuous current service, to do the same work; and every electrical engineer who has any experience thoroughly appreciates the difficulties involved in collecting large currents from moving contacts.

The arrangement of the collectors overhead, as on the Valtellina, and as proposed for the Inner Circle Railways, have the enormous advantage that all contacts are always in sight, while with the central-rail system they are under the train. Every linesman knows the advantage of that. The naked conductors overhead can be made as safe, or safer, so far as shocks to human beings are concerned, as the third rail. Obviously also the overhead conductor, inside a tunnel, can be made as strong as you like. Crossings, of which so much has been made, should be able to be arranged much more safely with overhead conductors, though there are two of them, than with the third-rail system, which involves serious difficulties.

The matter of the acceleration has been shown by M. Kapp's measurement to be a bogie, raised by the advocates of the 500-volt system. M. Kapp obtained the full acceleration required for the Inner Circle, namely, 1·55 ft. per second per second, under less favourable conditions than will rule on our Underground, while it has been also shown that all

that can be done with continuous-current, in the matter of controlling speed, braking the train, &c., can be done at least as well with the polyphase system. Practically Professor Ewing described the so-called continuous current accurately as a mixed system. It might also be accurately described as a transition system. It has been leading the way for the simpler and more economical arrangement of the complete polyphase system. The incidental fact that the complete polyphase system saves a considerable sum in first and running cost, owing mainly to the absence of rotary convertors, and to the use of smaller currents, will affect the travelling Londoner in his most sensitive point, his pocket.

British Locomotive Contracts.

A VERY unpleasant sensation has undoubtedly been caused by the announcement that a contract for 50 Indian railway locomotives has been placed with a German firm of engineers. Some perplexity has also arisen in the minds of those who have read recent correspondence on the subject. On one hand it is stated by Lord George Hamilton, in a letter to the *Times*, that the German tender was 25 per cent. less than the lowest British tender. As the most favourable British price was £1,990, it is to be assumed from the letter by Lord George that the German price was £1,492 10*s.*; and we do not doubt that it was actually within a few pounds of this figure. It would, however, be satisfactory, for several reasons, if the precise sum could now be divulged. On the question of delivery the case is not clear from complication, for whilst the tender of Messrs. Kerr, Stuart & Co. at first guaranteed delivery commencing in 36 weeks and ending in 52 weeks, the time was afterwards reduced to 30—46 weeks, being at the rate of 1·08 locomotives per week. According to Lord George Hamilton, the German tender offered delivery in "about half the time," a very vague expression that ought to have been avoided by the officials who are now, to some extent, on the defensive. Does "about half the time" mean 15—23 weeks or 18—26 weeks, or may the approximation cover a greater radius of gyration? Definite information on this point is surely to be desired.

Before writing to the *Times*, the Indian Secretary had reasonable grounds for supposing that British locomotive builders had some excuse for stepping on his toes. He has adopted the well-known precautionary device of stamping upon theirs, and, no doubt acting upon the advice of persons affecting to know the facts, he has read a very pretty lecture on the assumed deficiencies of the home locomotive industry. For the moment we will put this aside and confine attention to points arising directly out of the facts stated above. To begin with the question of price, it may well be that a German firm may be found willing to undertake a first order with a bare margin of profit, with no profit, or even at a loss. Such policy is not uncommon when a new and desirable connection is the goal, or when the maintenance of output at a theoretical loss produces saving in other directions. It is also familiar in a time of industrial depression such as that now being experienced in Germany. But there may be the further reason for a lower price that vexatious restrictions, imposed as usual on British trade, have been relaxed in favour of the foreigner. We cannot speak with certainty because, on this point, the India Office is silent. The same desire to open up a new field for trade, the same reason of industrial depression, and the same possible relaxation of restrictive clauses may, one or all, affect the question of delivery as well as that of price. Taking the case as it stands, it does not appear that the home locomotive industry need fear Continental competition so much as the Government, by which it should be encouraged in every legitimate way. Although the India Office is not the only tax-supported Department that strives to throttle enterprise by empirical specifications and unnecessary conditions, we may well point to it as one of the worst offenders. All Indian engineering contracts suffer from the baleful influence of

Great George Street, where specification builders are made, as elsewhere locomotive builders are made. It is no good for a maker of locomotives to prepare standard designs; it is of no avail that he can complete machines from such designs in a few days, for the maker of specifications will not accept them, nor trust the builder as other men are trusted So, cunningly-worded requirements are set forth, and work being thereby delayed, it is said that the British engineering trade has been tried and is found wanting.

In another direction British manufacturers have reasonable ground for dissatisfaction with regard to the recent diversion of trade to Germany, for it is evident that circumlocutory methods are largely to blame for the urgency of the contract. The officials of any concern managed on business-like principles would have known long ago of the necessity for renewals of plant, and would have made arrangements in advance. But the India Office seems to have awakened one morning to the fact that fifty locomotives were wanted at once, and owing to want of forethought to have been compelled to accept a tender for cheap engines, simply on account of a promise that delivery would be effected a few weeks quicker than British firms could guarantee. Whilst we gladly acknowledge the concern expressed by Lord George Hamilton that Imperial contracts should be placed abroad, we do not accept him as an expert in matters of trade, nor do we regard as satisfactory the excuses which he has been prompted to make for his Department. British locomotive builders are ready and anxious to make still greater efforts for the purpose of supplying the needs of the Indian Government and of the Colonies, but they get small encouragement, and are hampered by impediments not of their own making, and are frequently prevented from taking up contracts by circumstances entirely beyond their control. We cannot at the moment afford space to discuss in detail the large question of standardisation, although it may be remarked in passing that within certain limits it would clearly be beneficial. By this expression we mean that standardisation agreed upon between the leading makers would be a distinct gain, whereas if arrived at by theorists and perpetuated in cast-iron form by a Government Department for the guidance of future generations, it would be an unmitigated evil. As a matter of fact, obsolete and most stringent standards of weight limitation already constitute a serious difficulty in connection with rolling stock for Indian railways, and effectually prevent the adoption of locomotives of modern dimensions and weight. The official mind, whether it is found in Whitehall or in Great George Street, is incapable of considering the British manufacturer except as a person to be harassed, restricted, and watched. The foreign manufacturer, protected and encouraged by his Government, is believed to receive far more favourable treatment than our own. We are not advocating absolute protection, but we maintain that British engineering firms should be freed from excessive interference, and should receive far more encouragement and consideration than are meted out to them under existing circumstances.

Inventions and the Manufacturing Trade.

A LARGE and increasing number of Patent applications are filed every year in the British Patent Office, and a still larger number in the United States. Most of these are never heard of again, and for this there is one very obvious reason, viz., that the greater proportion of them are worthless. The ratio of inventions dropped to those which are carried on to the point of utilisation is very much larger here than in the United States, and this may be in great part accounted for by the fact that practically every application, the wording of which approaches comprehensibility, is accepted by our Patent Office even where it is obviously old, or, upon the face of it, absurd; while in the United States the worst of these classes are weeded out by the examiners.

In America, when an inventor brings any suggested improvement or develop-

ment before a manufacturing firm, he can be almost certain of having it considered on its merits, and of its being adopted, if approved. American firms are almost invariably eagerly on the look-out for improvements. Again, if it is on such a scale, or of such a nature, that it can be most profitably worked on an independent basis, he finds no difficulty in having the matter considered by financiers, and if in their opinion it is commercially promising, he will have no difficulty in getting it placed on the market; whether he will be satisfied with the share left for him is another question. Here quite a different state of things prevails. There are British firms who are on the look-out for improvements and ready to adopt any which will pay them; but they are few and far between.

What is required in the interest of our manufacturing industries is a system of selecting from the mass of new inventions ever pouring forth, those which appear sufficiently promising to be worthy of a trial, and the provision of means whereby those selected may be thoroughly tested, and, if approved, brought to the knowledge of our manufacturing firms.

There are at present men in London who, by taking up carefully selected inventions, and working them, or placing them on the market, have enriched themselves and benefited the trade of the country, and some at least of them have at the same time earned a reputation for treating every inventor with whom they have had dealings, not only fairly, but generously. What has been done by a few on a comparatively small scale could be done still more effectively on a large scale by a powerful association preferably composed, to a large extent at any rate, of men with a considerable stake in the manufacturing trade of the country.

The methods adopted would simply be an extension of those already successfully tested on the smaller scale. The association would have at their disposal the services of technical and commercial experts in all the various branches of industry, and arrangements would be made for the trial of such as passed the ordeal successfully either at the works of members of the association, for which they should, of course, be adequately remunerated, or elsewhere, as might prove most convenient in each case.

A very large proportion would be rejected by the experts on examination; a small proportion would come through all the trials and be pronounced sufficiently promising for the association to be prepared to take them up on terms which would be remunerative to them and to the inventors. A larger number would, in all probability, be adjudged of doubtful commercial value, and in such cases the association might possibly offer the inventors to give them a trial, provided they could find the sum necessary to cover the expenditure in the event of failure, which sum would, in general, be much less than it would cost the inventor to exploit his invention on his own account, while the prospects of success would be enormously increased.

In order to provide the necessary capital for working such a scheme, the association would probably have to be constituted, in the first place, on ordinary company lines; but provision should be made to allow of every manufacturer of repute becoming a member and acquiring some financial interest therein.

As the association increased in influence and general resources, it might take up many other questions affecting the interests of the manufacturing trade. For example, one of the first of these, if indeed it were not taken up from the very start, would be to assist manufacturers, if requisite, in obtaining compulsory licences on reasonable terms for working foreign Patents which were not being worked in this country by their owners, but only employed in order to throttle British industry.

We have purposely only outlined a scheme at present as a basis to start from. In order to be a success it must be widely supported, and that means that when it comes to formulating details there will be many interests to consider and many opinions to be weighed before the scheme can come to fruition.

The editor cordially invites correspondence from manufacturers and others interested in such a scheme.

Brooklyn Bridge.

FURTHER light is thrown upon the causes responsible for the partial failure of the Brooklyn bridge, by the Report now made public. It may be convenient to mention that shortly after the breakage of the suspenders, to which some reference was made by us in a recent issue, District Attorney Philbin instructed Mr. E. Duryea to make a careful examination of the whole structure. With the view of expediting the work and of adding to the value of the examination, Mr. Duryea suggested the appointment of Mr. J. Mayer as a joint investigator. These two gentlemen had previously been associated in connection with designs for the proposed Hudson River suspension bridge, New York, and each was therefore quite acquainted with the capabilities and methods of the other. In the survey of the Brooklyn bridge, the actual inspection was largely performed by Mr. Duryea, and to him are also due an appendix covering all the mathematical calculations, and another appendix dealing with improvements in the stiffening system. The body of the Report itself and the remaining appendices are in the main written by Mr. Mayer. But it should be noted that every part, both of the Report and the appendices, has been discussed and finally approved by both engineers. After careful perusal of the documents, we are sorry to say that the evidences of culpable neglect on the part of those in charge of the bridge are accentuated to a remarkable degree; also that the neglect accidentally brought to light by failure of the suspenders has acted most prejudicially throughout the whole of the structure. More than this, the Report makes clear that some original details of construction are of imperfect design, whilst others are inadequate for the additional loads placed upon them which were never contemplated by the designer. Thus it becomes evident that something much more serious than local failure is involved, and the Report is emphatic on the point that, as regards supervision and maintenance, the whole main span and the cable saddles on the towers are in a highly undesirable state. The recent inspection included a searching examination of the main span, and an exact computation of the stresses due to existing dead and live loads, with the result that the engineers express the opinion that the present perfunctory methods of inspection will not suffice to maintain the bridge in a safe condition for traffic, and that the increased loading has so reduced the margin of safety as to render repairs and strengthening details urgently necessary. Adverting to the mishap of July last, the engineers say that bending strains were the cause of failure of the suspender rods, partly due to making up of the trunnions and partly to the absence of provision for side play resulting from wind pressure. In fact, they express the belief that wind pressure alone was sufficient to break the rods, and they seem inclined to think this is what actually happened, though the accuracy of this view is somewhat open to question. The condition of the cable saddles on the top of the towers will be better appreciated if we state that they rest on rollers originally intended to provide for longitudinal movement, permitting the cables to accommodate themselves to the variations of load upon the spans of the bridge. Of course, the merest novice will know that such an arrangement must be cleaned and oiled at regular intervals, but the resident engineers either did not know this, or, knowing it, neglected to act upon their knowledge. On this point the Report says that no efforts were made to maintain the proper working of the saddles, ridges of rust, paint, and dirt being found on the bed-plates along the outer rollers. The natural consequence was that the saddles became fixed, and the cables being thus incapable of adjustment exercised an uncontemplated and undesirable drag on the tower tops, tending to pull them out of the perpendicular. Taking other examples of neglect, we find that in many cases the

diagonal bars and sway-rods have been considerably reduced in sectional area by frictional contact one with another, and some of the suspender ropes have similarly suffered by rubbing against the promenade floor. Water, mud, and road sweepings were allowed to collect and remain in various cavities of the chords and floor girders, a number of the stirrup rods of the suspenders were found to be improperly adjusted, and the stirrups themselves were partly buried in *débris*. The inspection of the bridge appears to have been left entirely to mechanics, who were too lazy or too ignorant to discover the existence of fractured parts, and the engineers had no proper plans of the structure, and were sublimely ignorant of the dangers to which it was subjected. As to the stresses set up in the structure, the Report contains a great deal of interesting matter, to which we can only make the briefest reference. The main cables are now called upon to withstand a maximum stress of 75,400 lbs. per square inch, and assuming that a certain proportion of the load is borne by the stays, the remaining stresses would probably not be less than 71,000 lbs. to the square inch, or 18 per cent. more than the safe working stress. Moreover, it must be remembered that the wind pressure causes a further considerable stress, the extent of which has not been determined. The masonry of the towers, owing to the condition of the saddles, suffers nearly double the strain which is permissible, the floor system is similarly overloaded, and the timber stringers of the railway tracks have to endure a strain of 1,750 lbs. per square inch, instead of 1,300 lbs., as would be safe. Various alterations, having for their object the strengthening of the bridge, are discussed in the Report, and it is estimated that the cost should not exceed £150,000. No doubt an early decision may be expected with regard to the question of repairs and reconstruction, but in any event it is perfectly clear that the control of the structure should be at once placed in the hands of conscientious and competent engineers, charged with the inauguration of a proper and scientific system of inspection.

Shipbuilding Statistics.

It is an old saying, and a wise one to boot, that with figures you can prove practically anything, and there can be no doubt that, to the uninitiated, statistics are a delusion and a snare. In order to render statistical data useful, it is essential that the basis underlying them should be fully known, and that the source from which they are taken and the method used in classifying them should be clearly stated. Above all, however, where figures are given for the purpose of comparing the efficiency, the output, or any other important quality of two or more devices or concerns, it is of vital importance that the figures in every single case, and in all the cases to be compared, should have exactly the same meaning and stand for exactly the same thing, or that, when this is not the case, the reason for the deviation, as well as the full extent of the difference, should be carefully and unambiguously indicated. Otherwise the whole comparison is valueless.

We fully sympathise, therefore, with a number of our correspondents, experts and men of high standing in the shipbuilding trade, who request us to direct public attention to the totally misleading character of the annual returns of shipbuilders' tonnage as published heretofore at the end of each year. These returns, it is true, represent in a fairly correct manner the total tonnage turned out in this country, but do not enable us to form an even approximately true estimate regarding the relative importance of the individual firms for the shipbuilding trade. Some of them make a speciality of construction work, while in others the engine-building department is the prominent feature. Such differences should certainly be indicated; and it seems to us that the following suggestions, made to us by one of the leading North of England firms, deserve very careful consideration:—

1. The tabulated data in the annual return should contain a statement indicating whether, or not, the shipbuilder referred to builds his own engines.

2. A separate return should be made dealing exclusively with the output of the marine engine builders, whether they be, at the same time, shipbuilders or not.
3. In the returns referring to shipbuilders only the i.h.p of the engines should be omitted, as these engines were supplied by another firm, and their i.h.p. would, of course, be found included among the output of the firm in the separate list of marine engine builders above suggested.

Moreover, in order to get rid of a very confusing and misleading feature and to obtain the necessary uniformity in the data referring to tonnage, the Board of Trade gross tonnage alone should be given, and nothing else. It seems advisable, for the purpose of carrying out this suggestion, that trade journals and other organs of the press, when applying to the various firms for data of the year's work, should mention distinctly that "the exact tonnage, as calculated officially by the Board of Trade and as inserted in the builder's certificate," is the tonnage wanted. As matters are, up to the present, only a limited number of shipbuilders give the gross tonnage, while among the others some include in their figures large spaces not generally counted, while others give a round figure, without giving any indication with regard to the way in which this figure has been obtained. There may be, perhaps, other methods of securing the desired uniformity, but until the above-mentioned defects in the annual return of shipbuilders' tonnage are removed, the statistics published have very little value, and give advantages to the less scrupulous by enabling them to inflate the figures of their annual output in an illegitimate manner.

OUR SUPPLEMENT PLATE . . .

In our last issue appeared an article on the subject of the three-crank vertical engines built by Messrs. Browett, Lindley & Co., Ltd., of Patricroft, Manchester, for the Electric Lighting and Tramway service of the Salford Corporation. We were unable at that time to publish any of the drawings, but an opportunity has been afforded us to do so now.

Full details of these interesting engines will be found on pp. 470—472 of the last number.

Sir William H. White's Resignation.

THE resignation of the Director of Naval Construction, at the age of 56—*i.e.* at an age when, under ordinary circumstances, his country might have been entitled to hope that he would continue for many years yet to direct, by his genius and vast experience, the further development of that noble fleet of which he has justly been called the creator—marks an event in the history of our Navy the full consequences of which it is impossible to foresee at the present moment, but which are sure to be far-reaching. The statement on the part of the Admiralty, officially promulgated, that there are impending a number of important changes in the administration, by means of which the designing of warships will in future become, within certain limits at least, a matter of public competition, would have to be considerably amplified before we should care to discuss it. So much, however, may be said at once, namely, that if this is intended to be a kind of set-off against the void left by Sir William H. White's retirement, the Admiralty will find that there are many in this country who are not prepared to consider the advantage of the change promised, even in its most favourable interpretation, an equivalent for the loss that the country suffers by the disappearance of a man of Sir William's qualifications from the field of action. However able and well instructed his successor may be, he will find it a hard task to fill even in part the place rendered vacant by Sir William H. White on his retirement. As a slight token of our admiration and esteem, we present to our readers, on the cover of the present issue of FEILDEN'S MAGAZINE, a portrait of Sir William, whose merits nobody will be better able to appreciate than the members of the engineering craft.

"SCIENCE ABSTRACTS," a monthly digest of the best papers read before the principal Scientific Societies, and issued under the auspices of the Institution of Electrical Engineers and the Physical Society of London, will be published on and after Jan. 1st, 1902, by the FEILDEN PUBLISHING CO., LTD., who will now forward a sample copy of this useful publication post free for 2s. to any applicant.

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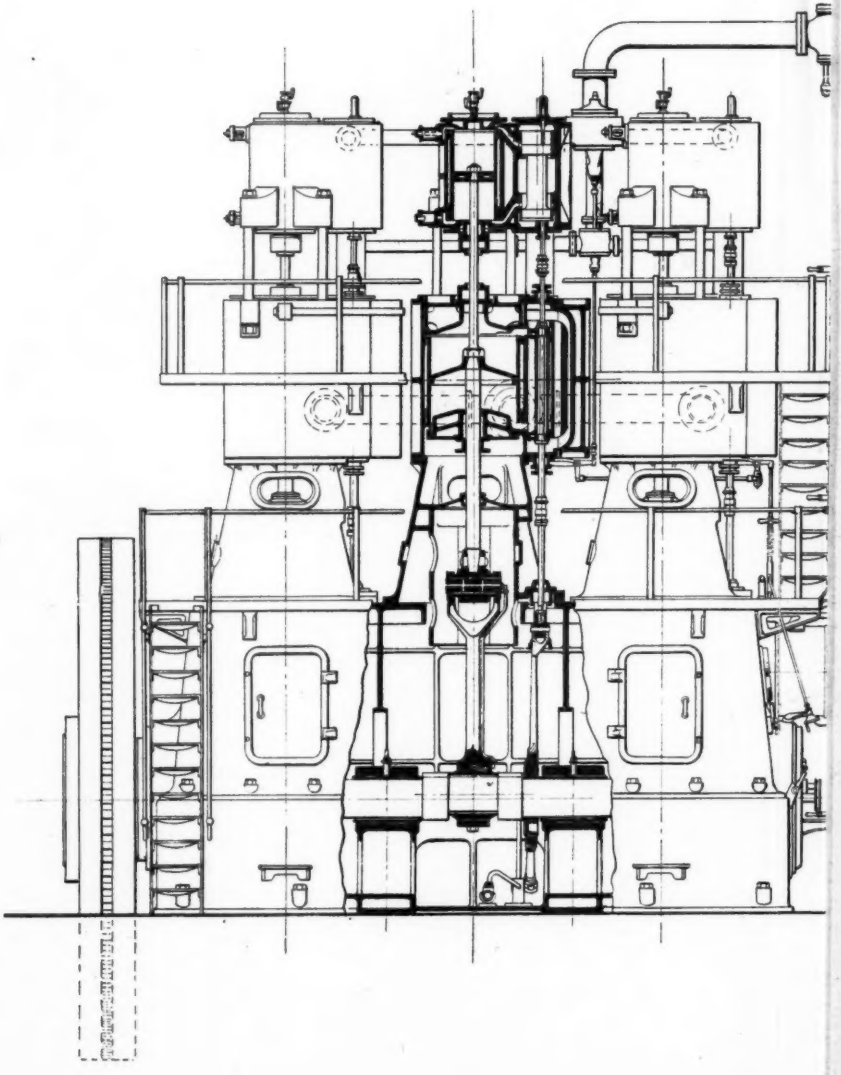

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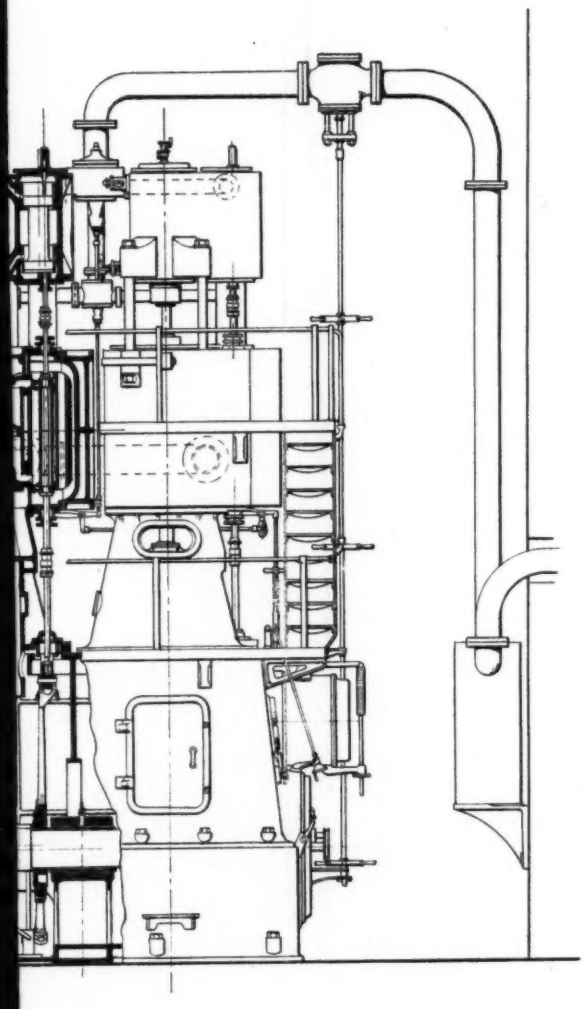

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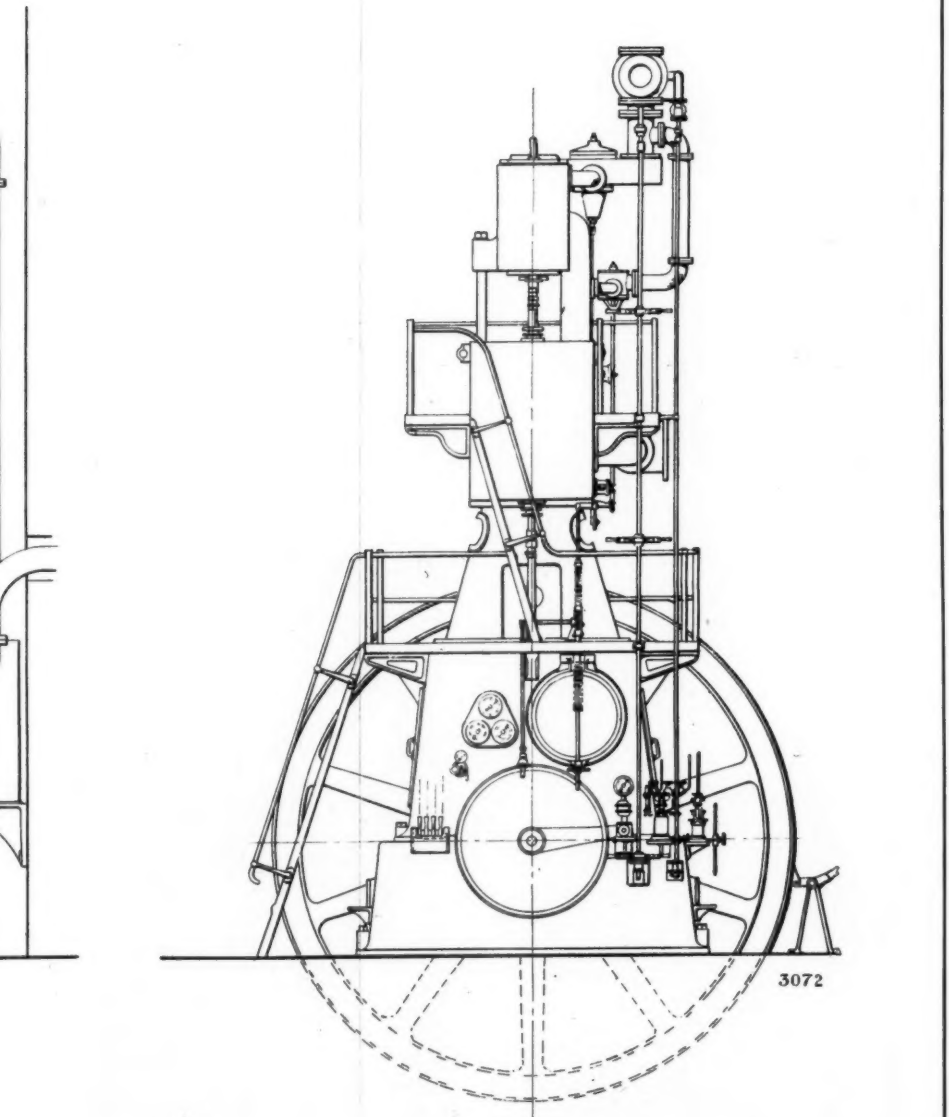

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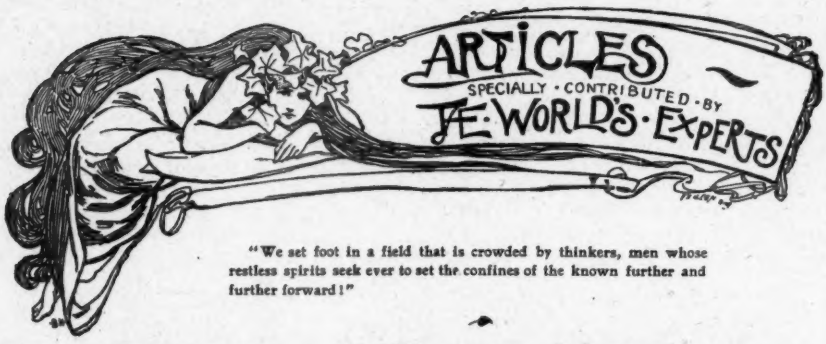


"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

The Application of Electric Motors.

By T. W. SHEFFIELD, A.M.I.Mech.E., A.M.I.E.E.

THE author of this article served his apprenticeship with the well-known firm of Messrs. Laird Bros., of Birkenhead, where he acquired a considerable experience in electrical matters. He subsequently became interested in a business in Manchester devoted to Worm-wheel Cutting, relinquishing this to enter the service of the British Thomson-Houston Co., Ltd., as District Manager

Mr. Sheffield's *forte* is the adaptation of electric motors for driving purposes, although the study of tramway management and economics has occupied much of his leisure time. His views on the latter subject are daringly original, and our readers will shortly become acquainted with them in another article from Mr. Sheffield's pen.

THE ever-increasing tendency to apply electricity as a motive power to machinery hitherto using gas engines, steam, etc., is sufficient apology for the introduction of this subject. The end to be attained is greater efficiency and economy, and in order to demonstrate that this most desirable result can be obtained by the introduction of electric motors brief reference will be made to several instances where they have been successfully applied in workshops, factories, etc.

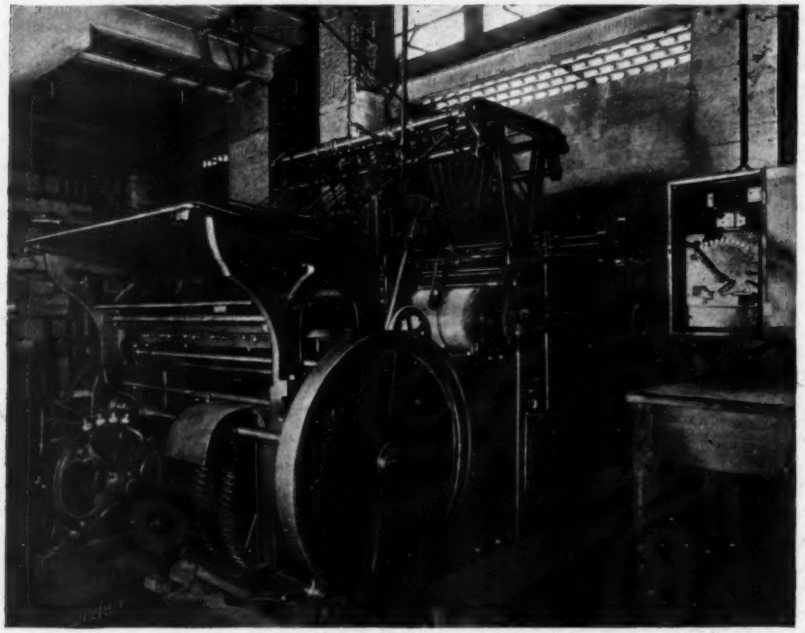
GENERATORS.

Electrical generators have now reached such a high standard that the loss due to the conversion of mechanical power from the prime mover into electrical power at the generator terminals is reduced to a minimum, generators of the larger size reaching an efficiency of 96 per cent. The latest and most modern practice for the operation of electrical generators is that which is known as direct driving, and in many cases the generator is so incorporated in the construction of the engine as to form really only a part of a complete machine, rather than a machine entirely separate from the engines. In the larger generators the armature in what are known as direct-current machines is pressed on the engine shaft, and the field magnets, which are circular in form, are bolted to foundations

in such a position as to completely encircle the armature. These magnet frames are generally divided into two parts, either in the horizontal diameter, to admit of the top half being removed and a ready inspection of the armature, or in the vertical diameter, and arranged on slide rails with a screw attachment to admit of either half of the magnet being removed laterally, leaving the armature completely exposed for inspection or repairs.

Generators for a power or traction load are generally designed for a standard voltage of 500 volts at no load, and are compounded to give 550 volts at full load, the extra pressure being required to compensate for the drop in the cables due to the increased current density.

A modern traction or power generator of the larger size will stand an overload of 50 per cent. above their rated ampères at a normal voltage for one hour, and the increase in temperature will not exceed 55 degs. Cent. above the surrounding air. It will further stand this overload without injurious sparking and without any adjustment of the brushes, and it will deal with 75 per cent. overload momentarily. These features are important items in the use of electrical power as applied to industrial purposes in place of mechanical power, as the large overload capacity of the plant permits a smaller plant to be installed at a less capital cost where the load is of a rapidly varying nature, than would otherwise be possible.



MOTOR DRIVING A PRINTING PRESS.

MOTORS.

The rapid development that has taken place in the last few years in the application of electric motors to various machines for all kinds of manufacturing industries

has been rendered possible only by the high standard of perfection obtained in the design of the electric motor itself. This, together with its adaptability and the readiness with which electric power lends itself to application in the most confined and inaccessible positions, has assured the extensive adoption of electrical transmission of power.

A few examples showing the varied conditions which have been successfully met by the adoption of electric motors, and which prove the general adaptability of their application, will doubtless be of interest.

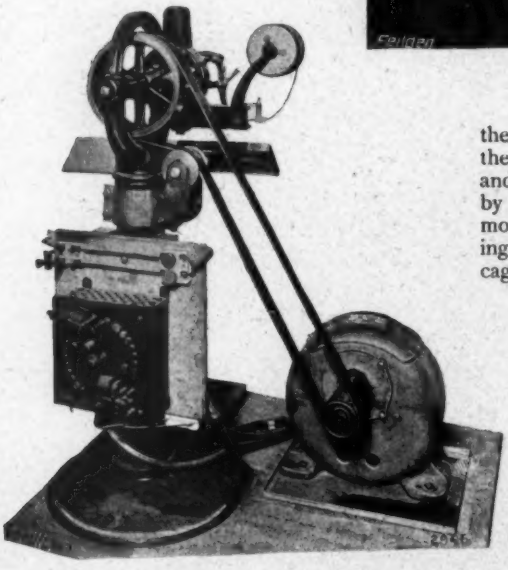
In shipbuilding, especially in the case of ironclads, which are often on the stocks or lengthened periods, and where electrical power is not available from a generating station in the yard in which the ship is being built, it will probably be found economical to put down a small portable plant on the dock side or slipway, supplying current to a distribution board fitted on the vessel itself, and from this distributing the power to any part of the vessel where it is required. The same plant could also supply temporary light in the vessel while work is progressing, thus enabling work to be satisfactorily carried on under healthier conditions than the present method of oil lamps, candles etc.

MOTOR DRIVING A CHURN.

Another example is the application of electrical power to coal-mining. Owing to the facilities in transmission which electrical power offers it has been widely adopted to operate portable pumps under ground, waggon ways by means of electric locomotives, and for lighting in mines both in the States and on the Continent; and the facilities it offers will

undoubtedly lead to its rapid extension in this country for similar purposes, and also for the operation of the winding engines. Several electrical winding plants have been installed in collieries in this country since the first application of this kind was successfully made at the Broad Oak Colliery, St. Helens, Lancashire, not very long ago. This plant consists of two British Thomson-Houston 25 h.-p. Type G.E. 52-56-turn motors working off the St. Helens Corporation tramway mains at 500 volts. The motors are lifting 50 tons of coal a day on a consumption of 576 units a month, at *2d.* per unit, which works out at *3s. 3d.* per day, thus costing the minimum sum of £4 16*s.* for 30 working days, which points out very forcibly

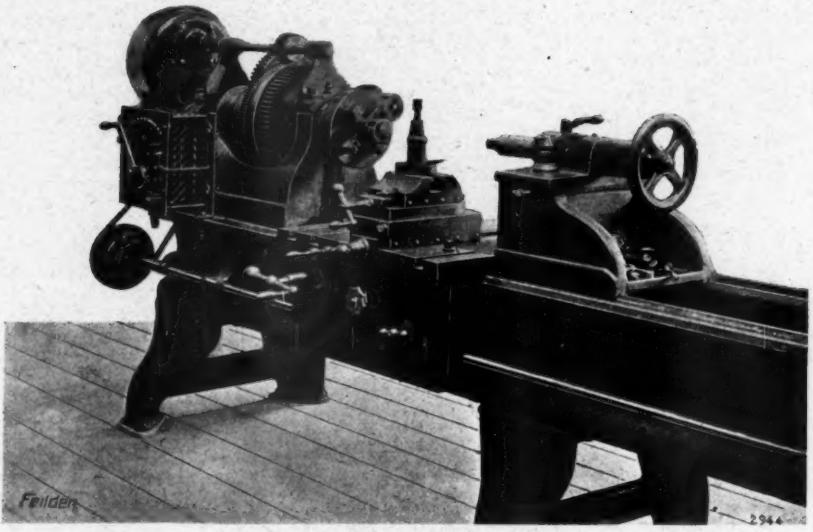
LATHE DRIVEN BY A MOTOR.



STICKING MACHINE DRIVEN BY A MOTOR.

the monetary gain in the application of the electric motor in this case. The plant and the controlling gear were designed by Mr. J. S. Highfield, M.I.E.E. The motor is peculiarly well suited for operating such a rapidly varying load as winding cages. It is found in practice that the motor or engine is not actually running for more than one-quarter of the working day, and it is because the power is absolutely shut off, and all expenses saved during the time that the motor is standing, that the cost of electric winding works out at such a low figure. The electrical plant adapts itself most perfectly to safety arrangements for preventing over-winding.

In the case of steel works or machine shops there is no question as to its superiority both in efficiency

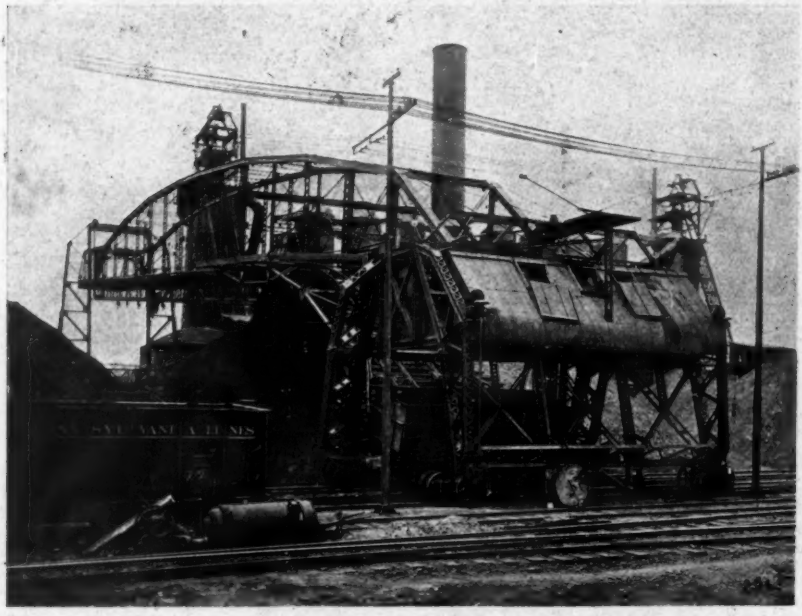


ANOTHER EXAMPLE OF LATHE-DRIVING BY A MOTOR.

or convenience, as individual tools can be operated at any required speed, if they are fitted with a separate motor, simply by a movement of the controller handle, without affecting any other machine; and the motor only absorbs power while doing work, and then only in proportion to the work done. The only question at issue in conjunction with this point is whether each tool should have its own motor, or whether one motor should drive a series of machines. The chief advantage of adopting the former method is the absence of all noise from the shops and the important fact that all shafting is done away with, giving increased light and the use of overhead cranes. In addition to this, if machine tool designers would incorporate a pedestal for the motor in their design in the first place, the motor and frame would take the place of the bearings and framework of other motion or gearing employed in connection with the belt-driven machine tools. The initial expense of small motors is the chief drawback to their adoption. No doubt one of the greatest and at the same time least recognised advantages of electrical driving lies in the fact that each machine is self-contained, and expensive foundations can be ignored. This, with the saving of belting and shafting, with less coal and oil bills, should be credited to the motor's initial cost. The great advantages of transmission of electrical power lie in the fact that there is practically no loss in subdividing and transmitting it over such distances as are usually met with in works; and in almost all cases the economy effected is shown to be so great as to cover the initial cost of the plant after a very few years. Further, the maintenance cost and repairs are reduced to a minimum, as the motor requires practically no other attention than that of oiling, and, instead of long lengths of steam-piping running through shops and yards, as is often seen at the present time, the whole of the steam plant is concentrated under one roof, and the motors are fed by cables from this central place to the various points of application. The loss in the cables may be reduced to a minimum, thus saving nearly all the loss otherwise incurred by condensation in the steam pipes. This, together with the elimination of the maintenance troubles

incident to a number of small steam-engines, is in itself a very great advantage. Further, the shops and yards may be lighted in the most perfect and efficient manner possible from the same plant that supplies the power, with only a comparatively small increase in the capital and working cost.

With regard to efficiency of electrical transmission, the following example, which we will require 300 h.p. in engine capacity. With an electric transmission, each machine requiring 5 h.p. or more may be driven by its own motor, and motors may be used where efficiency under average load is at least 85 per cent. Then to deliver 150 h.p. we require an input at the motor terminals of 176½ h.p. The loss in the line can advantageously be made less than 5 per cent., the only limit being the cost



MOTOR-DRIVEN ORE CONVEYOR.

is based on experiments in actual practice, is sufficient testimony to the extremely high efficiency attainable by this system :—

SHOP TRANSMISSION.

As a comparison between mechanical and electrical transmission, assume that we have to transmit power to machinery requiring 150 h.p. With a shafting transmission of average efficiency (50 per cent.) of the copper. Thus the generator must deliver 186 h.p. to the line; and as a generator of this capacity should have an efficiency at full load of about 92 per cent., the total loss from the pulley of the engine to the machine tool is about 25 per cent., or the efficiency of the transmission is 73 per cent. The required engine capacity would therefore be 202 h.p., whereas with shafting transmission of average efficiency a 300-h.p. engine would be needed.

ELECTRICALLY-DRIVEN CRANES.

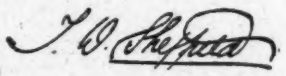
The problems involved in road traction are of a similar nature to those arising from the driving of cranes electrically, for in both cases we have frequent stops with rapid acceleration at no load and full load. The load varies within two wide limits, and energy must be conveyed to a machine that is continually changing its position. The ideal crane in lifting or traversing its load should start into motion slowly, accelerate quickly, and deal with the major portion of the hoisting or travelling at full speed, then slow down quickly to the stationary position. As it frequently happens that three motions are required to be in action at the same time, what is known as the three-motor system is frequently adopted, that is, each motion of the crane is operated by a separate motor; thus—one motor for hoisting, one for longitudinal travel, and another for traversing, which are all the motions on the average overhead travelling crane, and with which the ideal conditions above mentioned can be secured. The equipping of a crane thus results in a greater initial outlay as compared with a single motor equipment, yet the greater flexibility, economy, and safety thereby obtained greatly outweigh the excess of first cost. There are certain distinguishing features that are common to most travelling cranes, and whilst differing in minor details which result in no two cranes being exactly alike, the electrical apparatus for operating them has been designed upon such broad lines as to be readily applicable to all conditions of crane service used in engine shops and all manufacturing establishments.

PARTIAL SPECIFICATION OF OVERHEAD TRAVELLING CRANE AT DUBLIN TRAMWAYS STATION, DUBLIN.

Maximum length of longitudinal travel	141 ft.
Span (centre to centre) of gantry rails	78 ft.
Height of gantry rails from floor	27 ft.
Bottom chord of roof principal to floor level	35 ft.
Load, maximum	25 tons
Speed, longitudinal traverse, fully loaded	not less than 60 per min.
Speed, cross traverse, fully loaded	not less than 60 per min.
Speed of hoist, fully loaded	4 ft. per min.
Speed of hoist, loaded to 10 cwt.	50 ft. per min.
Height of lift (of load)	26 ft.
Longitudinal distance between centres of stanchions supporting gantry rails	25 ft.
Girder	6 ft. deep at centre; 24 ins. at ends
Crab rails	68 lbs per yd.
Crab wheels	cast-iron traverse; 12 ins. diam. chained barrel grooved
End carriage wheels double flanged	2 ft. 6 in. diam.; wheel base 12 ft.
Voltage of motors, 500.	

Simplicity in work and manipulation is certainly in favour of electricity, it being exceedingly easy for anyone without exertion to control a motor, and with the introduction of the latest controlling switches, a motor is under perfect control running at full speed, dead slow, stopping or reversing operations being performed in a few seconds.

It is impossible to conceive the range there is for electrical driving with motors, and many instances could be given apart from those mentioned—for instance, drilling, riveting, chipping, deck planing, and all tools in rock drilling. For these purposes the motor is far superior to compressed air, steam, or any other form of power, and recent applications of electricity in all classes of manufactures testify to the increasing demand for electrically operated machinery.



The Editor of FEILDEN'S MAGAZINE, whilst not absolutely pledging himself to any rapid revolutionary change, is of opinion that there should be no longer delay in the pursuance of a vigorous and aggressive line of action with a view to the modification of our fiscal arrangements, called for by the altered conditions of the times. He therefore invites, as a preliminary, criticisms and opinions from his numerous readers, with a view to a campaign which can rightly be described as of truly pressing National importance.

Important articles on the subject will appear in succeeding issues of FEILDEN'S MAGAZINE.

Machine Tools at the Glasgow International Exhibition.

By JOHN ASHFORD, M.I.Mech.E.

❀ ❀ ❀

II.

THE stay-at-home quite fails to realise the great advancement that has taken place during the last few years in methods of machining, although he may complacently imagine himself to be a thorough master of the subject.

Several months ago, at a meeting held at the Institution of Mechanical Engineers, a number of specimens of work were exhibited, produced upon tools of latest design, and attached to each was a label giving the times in which they had been machined. While looking at these a friend observed to me, "My word! one can scarcely credit it. I should like to get a number of these specimens and put them, with their labels, in a glass case upon a wall in our factory, that the men might see what can be done."

Yes! by going about and seeing what other people do, one can gauge the value of one's own doings.

The writer is in the habit of moving about in the engineering world, and in so doing sees and hears many things. Perhaps he may be pardoned if he seizes this opportunity, in writing upon machine tools, to ventilate some opinions thereon, although at first they may seem irrelevant.

As many people are aware, this Britain of ours has for several years past been subject to a commercial invasion, and in this, foreign engineers have played a prominent part. So far as machinery is concerned, this originated in the machine-tool trade. Much has been written blaming the British engineer that this should have been possible, but it would be easy for those who have a complete grasp of the question to exonerate the home engineer. At present that is aside from what we are dealing with. The point concerning us at the moment is the fact, that a huge demand for machine tools more handy and economical in use than those hitherto required, sprang up in this country at short notice, and the home builders were not ready to meet the demand. Coincident with this state of things here, American tool builders found themselves at the tail end of a boom in their class of goods, consequent upon the high tariffs placed upon imported machinery several years before, and they were able to produce more rapidly than was required by the state of their own market. That they were not slow to avail themselves of the opportunity thus presented for a market in this country, is now a matter of history. Many manufacturers here put down foreign machinery, and now, after the lapse of several years, have cause to regret that they were unable to obtain similarly constructed tools of home manufacture; for it has been found that those imported show signs of wear more quickly, and need repairs or replacing much sooner. A statement of this kind would be weak unless supported, and that support was found at the Glasgow Exhibition. Many firms, both British and foreign, who exhibited, had their machine tools in working condition with a view of demonstrating the work they were capable of doing, and in some cases the foreign ones showed what at first appeared to be superior results.

We all know that the value of a machine tool lies, firstly, in the satisfactory results produced in regard to accuracy in the product, and secondly, in the rate at which the same is produced. In the removal of metal in a machining operation

the ability to take a rapid and heavy cut is coincident with cheapness in production; thus the exhibitor is justified in endeavouring to prove that his machine will cut more quickly and remove a greater weight of material in a given time.

One noticeable instance of such a commendable effort may be ascribed to an American house, who were there showing the removal of cast-iron in a machining process at the rate of 130 lineal feet per minute. Seeing is believing, and it was there shown actually being done, to the surprise of many mechanical visitors. But seeing is only half the tale, as was found by a leading British engineer, who determined not to be outdone.

Obtaining some of the same tools treated in the same way, he failed to obtain more than 70 to 80 ft. per min. in his own factory, but invariably when that speed was exceeded the cutting-tool gave out. Subsequent inquiry brought to light the fact, that the castings upon which the high speeds of cut were done, and which were to become parts of the exhibiting firm's machines, came from the United States, and the additional fact was ascertained, that the high speed of cut was only possible by the extreme softness of the castings. Obviously, when machine tools are made with such castings as those referred to, they cannot possibly have the life of those made from the harder material used in this country. Tools made from this soft cast-iron, when put to work upon the harder material used here, cannot have even the life that they have in America, where engineers make it a boast that their tools go on the scrap-heap in ten years time.

There is a still further effect that the general use of either a harder or a softer material has, which is, in the design and scantlings of the machine-tools built. British tools are built of, and to work harder material. They are, therefore, more strongly and stiffly made; and, as a consequence, have a much longer life,

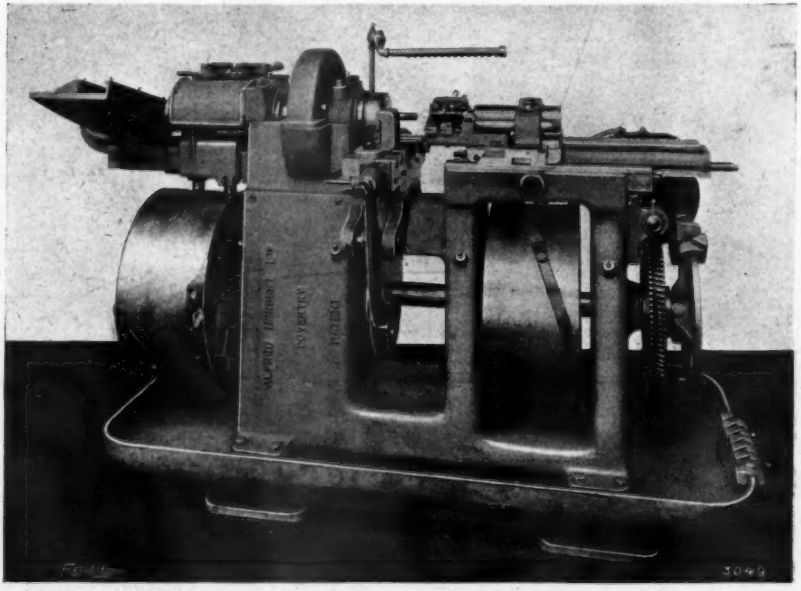


FIG. 14.—ALFRED HERBERT, LTD.: AUTOMATIC SCREW MACHINE.

while retaining their accuracy of alignment for a more extended period.

This argument on the materials side of the question, however, does not alter the fact that in regard to points of handiness and utility, and also in the matter of automatic machine-tools, foreign competitors have been able to give British builders a few points. That they have not been long left to enjoy their advantage in this direction, is well demonstrated at the Exhibition. Many firms have for some time past been busy setting their works in order and putting their designs to rights, with the result that some splendid tools are now being built which will hold their own anywhere on a level footing. Such is the conclusion forced upon one after careful inquiry and investigation.

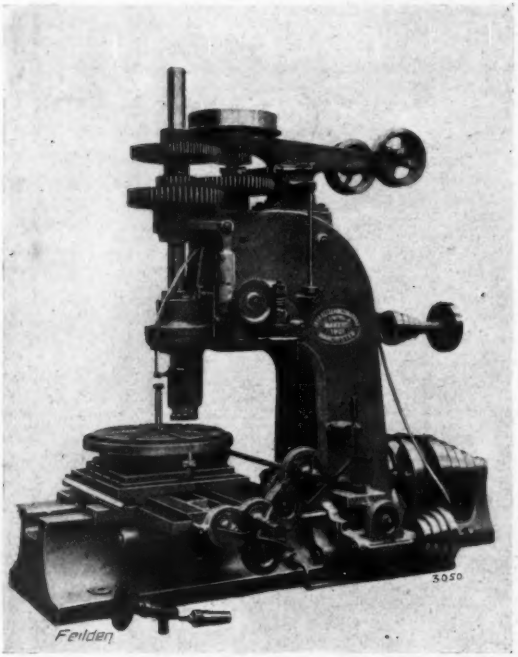


FIG. 15.—JOHN HETHERINGTON, LTD. : VERTICAL SPINDLE MILLING MACHINE.

Turning now more particularly to the machines at Glasgow. In addition to those referred to in my first article, as exhibited by Messrs. Alfred Herbert, there was a very wide range of full automatic screw machines, five sizes in all, each set up with tools and in motion, producing such things as ordinary studs, pins, bolts, bushes, electrical terminals, and other things of a more special nature. That illustrated in Fig. 14 is fitted with tools and a hopper feed to enable it to size and screw, as a second operation, the reverse end of studs that have previously been turned, screwed at the fore end, and cut from the bar on another machine. It might be observed in passing, that this machine, instead of being fitted with the usual rotating turret, has a cross-slide mounted in its place upon the longitudinal slide, carrying a sizing tool and a self-opening die.

We may, perhaps, for the sake of comparison, bring together several vertical spindle milling machines which show a tendency to press their way to the front. The developments are chiefly associated with the heavier machines, which have apparently been designed with a view to bringing the advantages of a continuously cutting tool to that work which has in the past been the special preserve of the slotting machine. As is, perhaps, natural in a process of development, these machines, in their aspects, have a general appearance somewhat resembling the slotting machines that, on some work, they are intended to displace. Fig. 15 is a machine of this class, built by Messrs. John Hetherington and Sons of Manchester. Its general proportions may be grasped from the fact that the spindle is 6 inches in diameter.

A study of the illustration will show that the lower end of the spindle takes its bearing in a sliding head, which may be

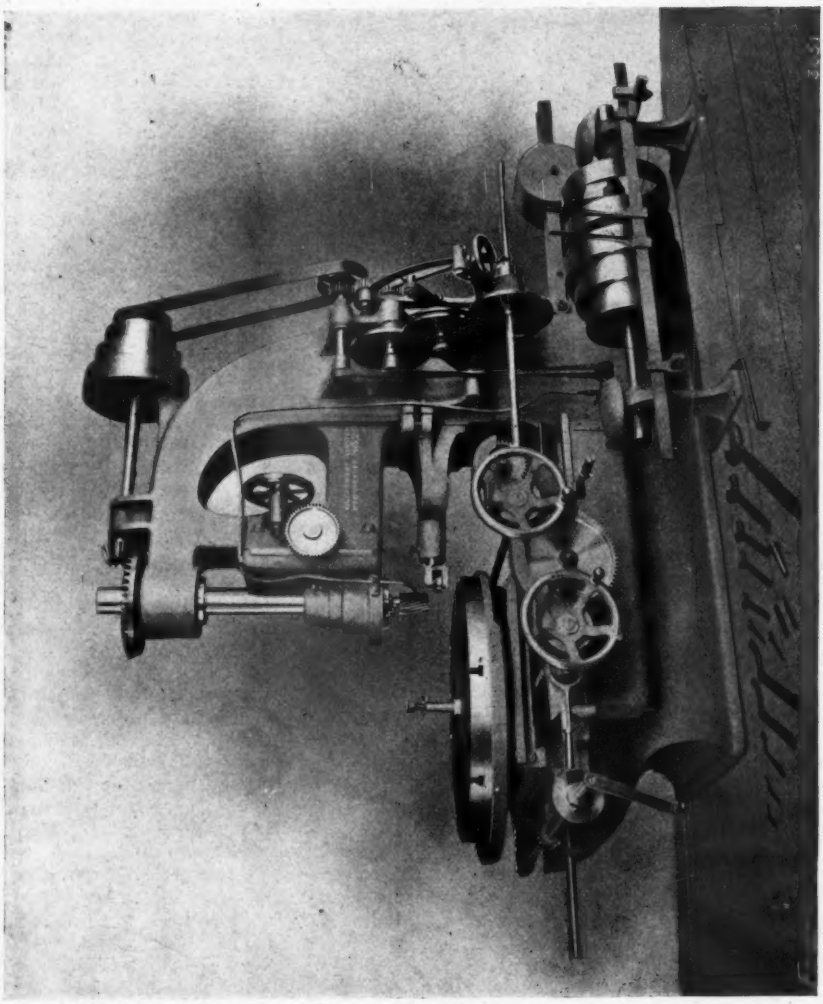


FIG. 16.—VERTICAL SPINDLE MILLING MACHINE, BY MESSRS. SMITH AND COVENTRY, LTD.

FIG. 17.—VERTICAL SPINDLE MILLING MACHINE, BY MESSRS. KENDALL AND GENT.

given a vertical traverse of 18 inches, the spindle and head moving together, so that the bearing shall always be close to the lower end of the spindle, giving it the greatest possible amount of support. To further stiffen the milling cutter and enable it to take heavy cuts, an adjustable bracket is attached to the lower end of the sliding-head to carry a support for the lower end of the cutter-arbor.

Powerful gearing is introduced into the drive of the spindle to suit it for heavy cuts, and there is also a lighter drive that may readily be put into action when quicker speeds of spindle are wanted. The work-table is mounted in a very similar way to that of a slotting machine with compound slides and a rotary motion.

Each of the feeds can be connected to an automatic drive, which has four speeds and reversing mechanism. For the assistance of the operator, the circular table is divided round its circumference into degrees, and each of the other slides is fitted with a scale rule along one edge, together with indicating pointers.

It seems to be considered desirable that a machine of this class should be able to profile irregular shapes from "former plates." When it is to be so used, the longitudinal traversing mechanism is put out of use, and a bracket is attached to the machine frame carrying a hard steel roller at its extremity. Against this a former plate, fixed to the work-table below the work, is constrained by the aid of a weight acting through a steel pinion gearing into the rack attached to the longitudinal slide.

A second machine, with the same general functions as that just described, may be seen in Fig. 16. It is produced by Messrs. Smith & Coventry, and differs in several respects, chiefly as regards details. The main drive of the spindle is, in this case, through a pair of bevel wheels without back gear. It may be observed that the machine actually illustrated is one of medium size, but to avoid misconception and erroneous comparison, it may be noted that it is made in five sizes, the largest of which differs somewhat in design.

The feed drive is through the series of friction discs mounted upon the side of the machine frame, which makes it possible to get a great range of speed, through the whole of which the mechanism may be rapidly carried without stopping the machine.

For copying irregular shapes a former fitted to the table is pressed against the adjustable roller carried on a movable arm, by a weight acting through a system of levers situated at the rear of the machine.

A still lighter machine of this type may be seen in Fig. 17, as manfactured by Messrs. Kendall & Gent. This also is made in larger sizes with back gearing, etc., for heavy work. This firm state that with this kind of machine it is possible to tool work, that had been previously slotted and shaped, at about one-third the cost

and with a superior finish. This is apparently the ground upon which this class of machine has been put upon the market. It is unnecessary to further describe details, as the motions and objects are similar to those of the others described.

The machine exhibited by Messrs. Hulse & Co. has some novel features (See Fig. 18). Perhaps the one that first strikes the observer is the method of mounting the spindle. It is placed within a hollow square slide, which is movable vertically through square guides in the frame of the machine, carrying the spindle with it, and when it is brought to its working position a locking screw in the lower guide is used to firmly fix the slide in its position. This slide then acts as a stiff support to the spindle, and it carries the lateral pressure due to the cut. A counter-weight, hanging inside the body of the machine, is connected to the square slide by a chain passing over guide pulleys, so as to enable the operator to easily make all necessary adjustments. With a view to further increasing the usefulness of this machine, there is a self-acting down-feed motion which may be used for drilling.

Before leaving vertical spindle milling machines, one manufactured by Alfred Herbert may be brought under notice. This is a much smaller tool than those already mentioned, and it is intended for a different class of work. Its function is to mill comparatively light articles, numbers of which are required, and in such work it would show to the best advantage.

The main table, or platten, is mounted upon a carriage and cross-slide, so that compound motions may be given to it, and these may be either automatic or hand-operated as required. For circular work a secondary table, to mount upon the platten, is provided, and for this a mechanical circular feed is fitted. Each of the motions may be automatically operated and thrown out of action by adjustable feed stops when the extent of the cut has been reached.

The spindle, mounted in a somewhat similar way to those of the machines previously mentioned—the lower bearing in a vertically sliding head—is adjustable through quite a convenient range. Thus, with the help of a movable steady-bracket bolted to the column, a stiff support is given to the cutter.

It is now a well-known fact that in the average engineering workshop the amount of power lost by friction in line-shafting, etc., is something enormous, and that the actual amount really absorbed in cutting away metal at the machine tools is quite a small percentage of the whole. Actual experiments have shown that a matter of

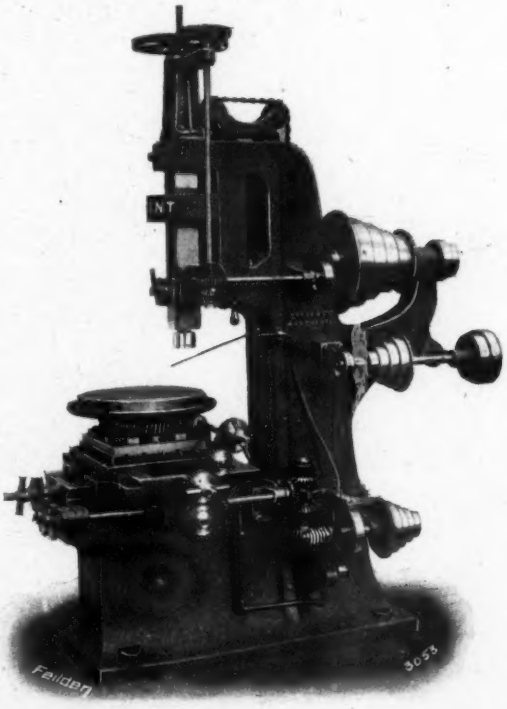


FIG. 18.—MESSRS. HULSE AND CO.: VERTICAL SPINDLE MILLING MACHINE.

50 per cent. of the total power is required to drive the line and counter-shafting with the machine-belts on loose pulleys. This percentage loss will be considerably increased when the machines are put on probably to about 65 per cent., thus leaving 35 per cent. of the engine power given to the shafting, as actually being used in the machines. Of this latter quantity quite a considerable portion is used up in overcoming frictional and inertia resistances. The worst offender in this matter is the planing machine. In it probably about one-third of the power is used during the cutting period, the balance being used up in absorbing the inertia when reversing the platten at the two ends of its stroke and during the return traverse. Of the one-third portion used during the cutting stroke, a portion is expended in overcoming friction, and the remainder in cutting metal. It enables us, however, to form some idea of the proportion of the whole work that would actually be utilised in cutting away metal in a shop full of planing machines, perhaps one-eighth or less of the 35 per cent. It seems incredible, but this estimate is actually based upon experiment.

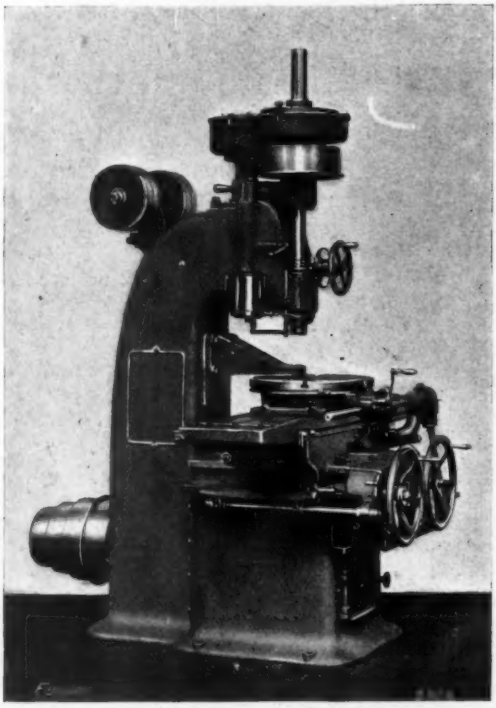


FIG. 19.—VERTICAL SPINDLE MILLING MACHINE, BY ALFRED HERBERT, LTD.

With machines such as lathes, which have a continuous cutting action, probably from 10 to 15 per cent. of the work would be found at the tool-point.

In these days of increasing competition, one is met with the very serious thought:—"Does it pay to put down line shafting with its attendant belting, etc., when electro-motors can be put directly to the machine?" And there is the second serious thought:—"Does it pay to put down reciprocating machines, such as planers, slotters, etc., with their heavy attendant frictional losses, where continuous cutting milling machines can be obtained?" When putting electro-motors to the planing machine, one of large size becomes necessary to meet the considerable variation in its load; but the problem of suiting the drive to the machine is much simplified in the case of the slow-moving miller.

As many readers will be aware, a number of different designs of plano-milling machines, or what some people call slab-mills, are now upon the market. That they continue to be pushed forward is evidence that there is a demand for them and that they sell.

Messrs. Kendall & Gent are marketing several different designs of these tools with both horizontal and vertical spindles, and one of their smaller size will be found illustrated in Fig. 20. But little explanation of the machine is necessary as its

general lines, so far as regard frames, plattens, etc., are so like the similar parts of the planing machine. The whole thing is intentionally proportioned, and the mechanism and cutting speeds are arranged to take the very heaviest cuts in wrought iron and steel. The sizes at present range up to 63 ft. in width, and 20 ft. as the longest cut. It seems likely that as these machines become better known and their economy of working realised, the demand for them will increase.

Of the various smaller types of milling machines, quite a considerable number are to be found included in the exhibits of foreign tools. It is not, however, the intention of the moment to deal with them, but to confine attention more especially to those of British construction.

There is one of British make, however, that should be looked at in passing. (See Fig. 21.) This kind of thing with box standard, overhanging vertically-adjusting knee, has been built in large quantities, and no doubt they are capable of doing some excellent work, but they do not appeal to the writer as good mechanically. The odd devices and tricks that are of necessity resorted to, in order to make the machine workable, give one an

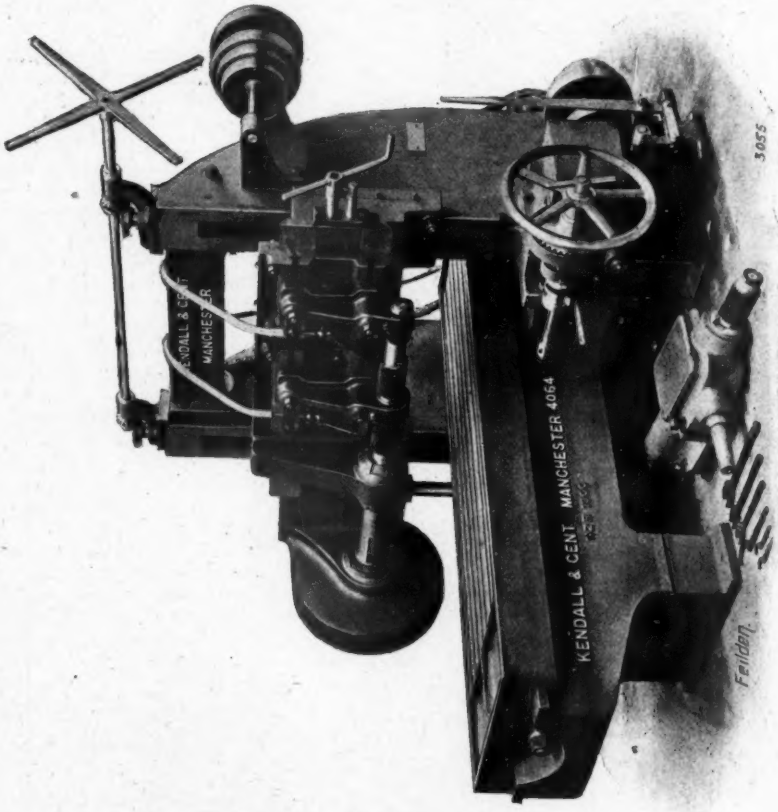


FIG. 20.—PLANO-MILLING MACHINE, BY MESSRS. KENDALL AND GENT.

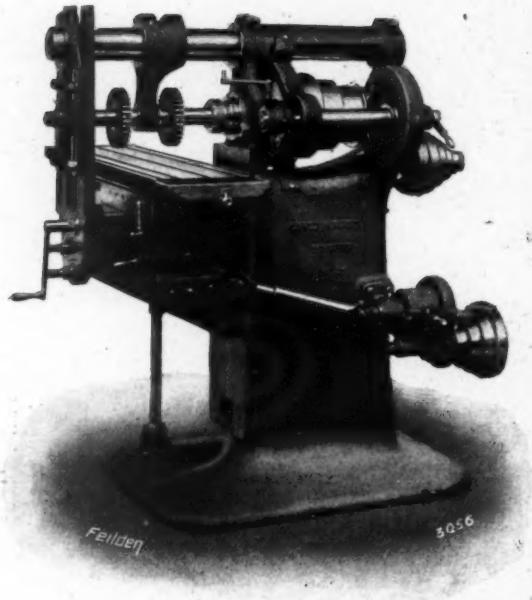


FIG. 21.—MILLING MACHINE, BY ALFRED HERBERT, LTD.

unpleasant feeling. One feels instinctively, when looking at a machine, whether or not it conforms with his mechanical instincts. To explain a little more in detail, with the illustration before us, the platten is carried upon an overhanging knee-bracket, which is pushed up or lowered down by the aid of a comparatively slender screw which dips down into a hole in the floor. The driving-mandrel is supported in strong bearings at the head of the pedestal, and then the cutters are fitted upon an arbor which projects out from its end. This arbor tends to spring out of alignment. The cure is to arrange an overhanging bar with firm fixings above the mandrel bearings, to support the arbor. The next disease to declare itself is a springiness about the projecting knee. The cure again is to extend the overhanging bar, and put some form of tie-rod between it and the knee. The kind of thing introduced into some of the designs of these machines is most unsightly. In the illustration before us, the device for this purpose is, to the

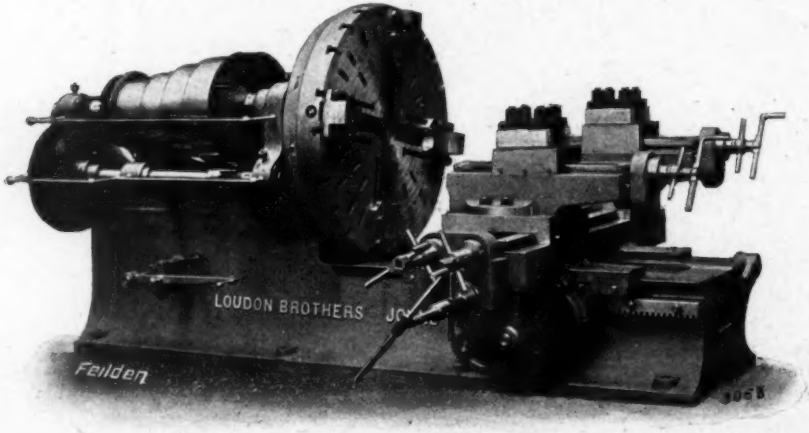


FIG. 22.—MESSRS. LOUDON BROS.: 48-IN. TRIPLE-GEARED DUPLEX SURFACING AND BORING LATHE.

writer's mind, about the best going, but that does not get over the fact that the whole machine consists of mechanical makeshifts to overcome initial defects due to the type of machine. Let it be clearly understood, that these remarks are not addressed to the particular make of machine illustrated, for that one is to the writer's mind as good a production of the type as is to be found. It is the *type of machine* that puts one's mechanical instinct on edge. Another point in support of this idea—the power for the feed traverse has to be conveyed to the platten, in whatever position it happens to be, through an inclined telescopic shaft with two Hook's joints. Thereafter beneath the table there is quite a little trick-box of bevel gears, clutches, etc. If we are obliged to concede that this type of machine is a necessity, then the one illustrated has little about it with which to find fault.

Messrs. Loudon Bros. of Johnstone are exhibiting several machines at the Exhibition, including a 48-in. triple-geared duplex surfacing and boring lathe. (See Fig. 22.) The whole machine gives one the idea of solidity and strength, and as being capable of tackling quite a variety of heavy work. The bed-plate is strongly formed and well-ribbed internally. Its bearing surfaces, upon which the saddle is to slide, are made broad. The head-stock is of good length and has a heavy forged steel spindle with large bearing surfaces, the one at the front end being $6\frac{1}{2}$ in. in diameter and 10 in. long.

At the Engineering Congress held at Glasgow, there was much discussion in the Mechanical Section on the Premium system of remunerating labour, and a statement was made to the effect that one result was a demand by the workmen for machines with greater belt power. The machine under consideration may possibly be the outcome of some such requirement, for the cone pulley, it is claimed, has been designed for wider belts than usual.

Considering the efforts that at the present day are being put forward by British engineers to increase the output of their various works, this fact, that by an increase in the width of belts upon given machines, the output of those machines may be considerably enlarged, is worthy of careful consideration.

The saddle is fitted with two compound slide rests, and they each may be operated from either the front or back of the lathe. The self-acting feed motion which is derived from a back shaft, is arranged to act both upon the saddle longitudinally, the cross slide, and the tool rest swivel-slides. This latter motion is of great assistance when turning tapers. There are three changes of feed provided, with a mechanism similar to that known as Lang's, and they are $\frac{1}{16}$ in., $\frac{1}{8}$ in., and $\frac{1}{4}$ in. per revolution respectively.

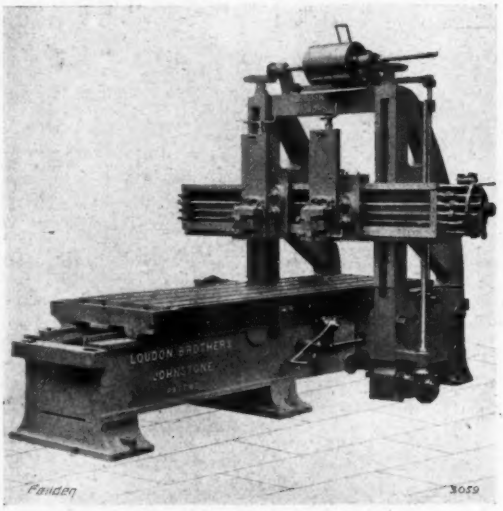


FIG. 23.—PLANING MACHINE BY MESSRS. LOUDON BROS.

The same firm are exhibiting a Planing Machine, $3 \times 3 \times 8$ (see Fig. 23). There are several innovations in this machine which are looked upon as improvements, as for instance, flat slide surfaces for the table with provision for preventing lateral

FIG. 24.—MESSRS. HULSE AND CO.'S SIDE-PLANING MACHINE.

movement when side cutting is being done; driving by two belts instead of one, with the mechanism arranged so that only one is moved at a time and each a distance only equal to its own width; also a deep and stiffly made cross slide, its length sufficient to allow the left-hand tool box to run clear, so that the right-hand one may take a cut over the entire surface that may be admitted between the uprights. Both tool boxes are independent, and are provided with self-acting motions in horizontal, vertical, and angular directions. The vertical slide is long and can be swivelled to practically any angle. The ratio of returned stroke to the cut stroke is four to one, and the range of feed extends from $\frac{1}{32}$-in. up to $1\frac{1}{4}$-in. in both horizontal and vertical directions, with a possibility of 40 changes between those limits.

Of side-planing machines there are several specimens, including those by Messrs. Hulse & Co. (see Fig. 24), Messrs. Smith & Coventry, etc. These tools are very useful on various classes of work.

A new two-spindle radial drill, by Messrs. Kendall & Gent, is a machine that fills a distinct gap in the usual array of shop tools, for it is made to drill and tap holes without change of either tool or speed. A whole series of holes may be drilled and tapped continuously without altering the speed of the machine. The tapping spindle automatically stops when the drill encounters excessive resistance, thus preventing breakage, and the tap is then withdrawn at twice the tapping speed.

FIG. 25.—BUFFER TURNING LATHE, BY MESSRS. P. AND W. MACLELLAN, DESCRIBED ON PAGES 357-8.

There were many other machines that one would like to draw attention to, par-

ticularly some fine tools by Messrs. Thos. Shanks & Co.; others by Messrs. J. Hetherington & Sons, Messrs. J. Holroyd & Co., Messrs. Richards & Co., etc. There were also the specialities by Messrs. Taylor & Challen in power presses, and the latest developments in circular and band saws by Messrs. Pollock, Whyte & Waddell. All these things are worth pages of description, but the limitations of space render it imperative to leave much unsaid. Foreign machine tools there were in plenty, crowds of them, in fact, and many of them well worthy of note. Some things have been purposely omitted from these articles, as it is intended to refer to them in the near future.

John Oldfield

[Since writing my last article, Messrs. Sharp, Stewart & Co. inform me that the exhibit of theirs described as Oldfield's Turret Lathe was the first of its type built, and that they have now added a pump to flush the tools with lubricant, and also automatic stops to arrest the sliding motion. These will certainly be valuable additions to the machine. J. A.]

Some Recent Developments in the Design and Construction of Groynes.

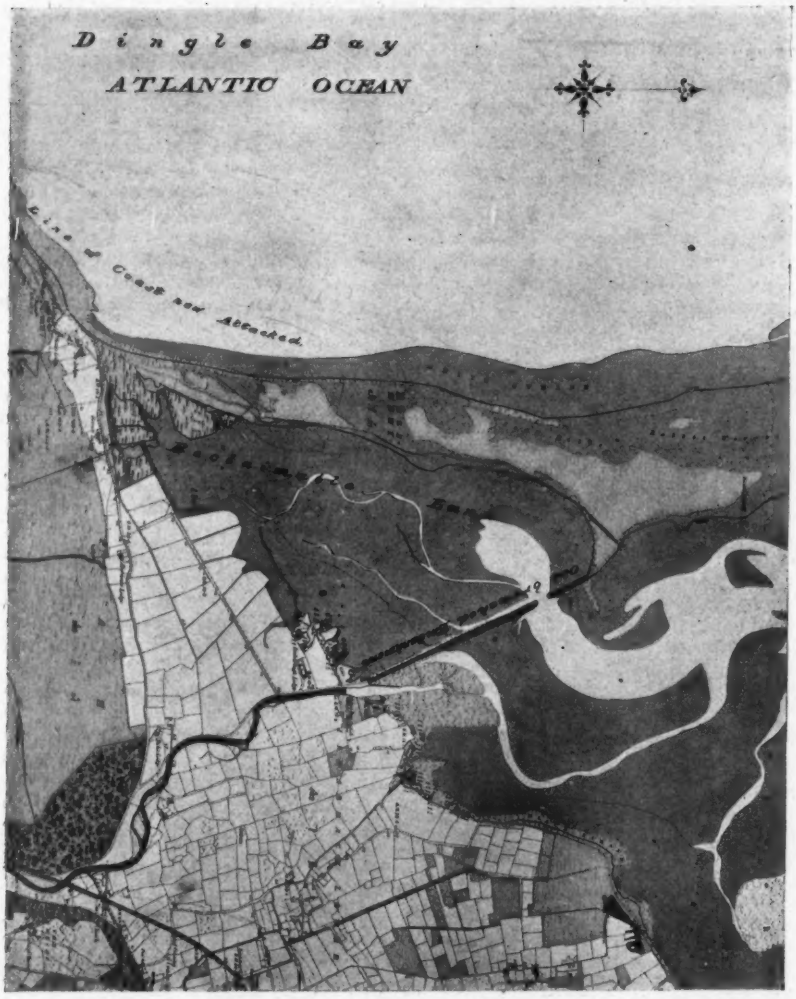
By R. G. ALLANSON-WINN, M.Inst.C.E.I.

Of the two chief means adopted for the protection of the coast-line from sea encroachment—groynes and sea walls—the former are probably the most worthy of consideration with the view to improvement and extension. If we attend properly to the groynes and are successful, through their instrumentality, in accumulating sand and beach, the sea walls and esplanade walls will almost take care of themselves. In other words, whenever a shore can be induced to take up a permanent and uniformly sloping surface, from low-water mark to some feet above high-water mark, a very light and inexpensive wall will be amply sufficient to hold up a roadway or act as retaining wall to a sloping and well-grassed cliff face. Such a wall will not be subjected to deep-water action, and will be amply strong enough to withstand any onslaughts of surface water or spray.

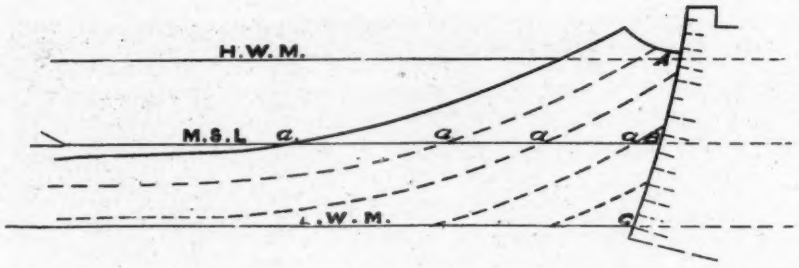
As regards the strength of sea walls, it is well to bear in mind the following points, along with many others which will doubtless occur to the readers of these pages. A wall which is to be erected on a rapidly disappearing coast, and which has to rely on itself, and itself alone, for keeping out the sea, must be taken well down to a line below low-water level. If this is not done and erosion continues, there will be constant expense in the matter of underpinning, sheet piling, etc. The foundations of the wall, to start with, must be below low-water level. It is easy to see from the typical section that, as the point *A* approaches nearer and nearer, the life of the wall, however strongly built, whose foundations had been only taken down to say *B*, a point somewhere about mean sea level, would become less and less valuable—from an insurance company's point of view. As the successive laminæ, represented in section by the dotted lines, are worn away the expense of maintaining the wall increases. So that if the wall alone is to be relied on, it is better to take its foundations well down below low-water level in the first instance, though the initial expense will be heavy.

We are thus at once confronted with the vulgar but inseparable question of £ *s. d.* Engineers can always keep out the sea if—and it is a very large if—they are given enough money to do the work. A visit to the East Cliff works at Dover, where the reclamation of many acres of land has been admirably carried out, will convince any sceptic of the truth of this remark. The Plymouth breakwater, the Holyhead breakwater, and the dam across the Nile are all examples of what main force and skill combined will do, and we won't admit that there is such a thing as an impossible project so long as there are sufficient supplies of materials, labour and funds.

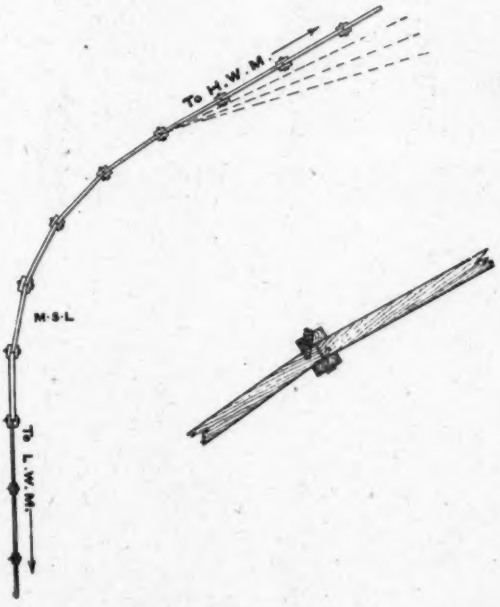
With foreshore protection works we have often to do our best to provide protection at very moderate cost or leave the job alone. The writer of this article was once called in to consult on a very difficult problem, connected with a sudden incursion of the sea over a definite line of coast. One of the gentlemen interested said, during the inspection, "Oh, it's easy enough; why don't you build a wall?" This gentleman, with all the refreshing confidence born of childlike ignorance, would have built a wall with foundations somewhere about a foot below high-water mark, which in the situation would have been absolutely useless. On working out the quantities for a real wall, it was found that the cost would be £30,000—a sum beyond the entire value of the property assailed.



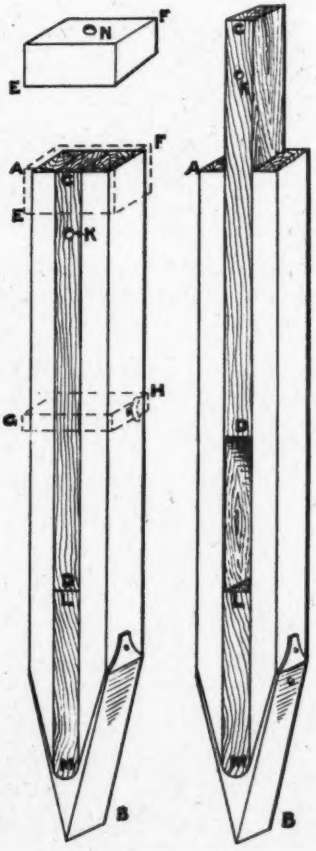
ORDNANCE SURVEY 1898. GLENBEIGH, CO. KERRY. SHOWING OLD BREACHED BACK-WATER AND FORESHORE DIRECTLY EXPOSED TO THE ATLANTIC.



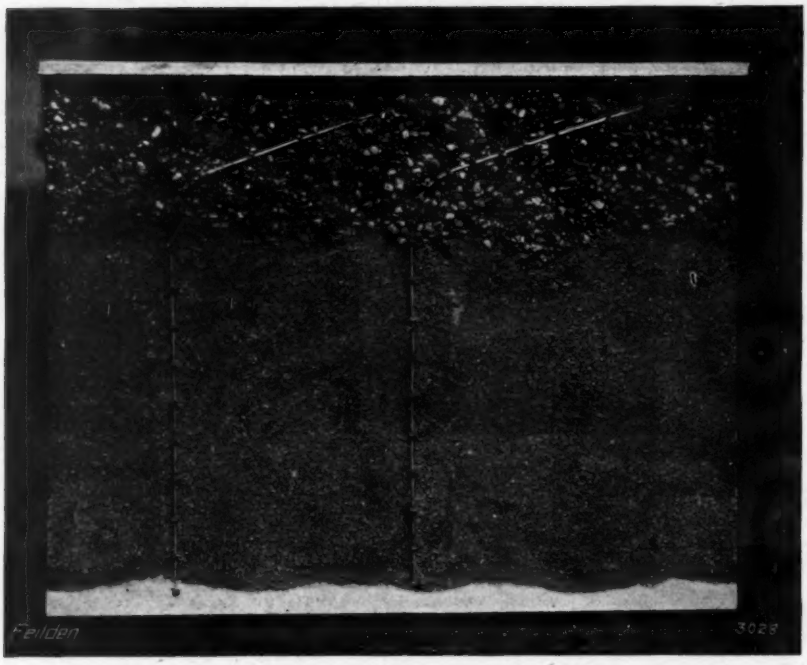
TYPICAL SECTIONS: CURVED SLANTING GROYNES.



PLAN OF CURVED SLANTING GROYNES.



LAMINATED PILE: CURVED SLANTING GROYNES.



MODEL OF CURVED SLANTING GROYNE.

Then there is another aspect, which should never be lost sight of by those interested in the improvement and protection of our health resorts, and that is the impossibility of really *saving* land or accumulating a fine healthy playing-ground for children by means of a wall.

In ordinary cases, then, and always excepting harbours and breakwaters, we have to provide protection at moderate cost. This is best done by holding the low-water mark and encouraging the sea itself to build up the shore. According to the writer's experience, this utilisation of nature's forces is best effected by the use of the low groynes devised by the late Mr. Edward Case, whose system has been previously described in these pages.

Given certain conditions and ample funds, any one with average intelligence and experience can build a good sea-wall; but it requires something more than intelligence to devise a means of utilising the restless, changeful forces of the sea in such a manner as to secure their services in carrying out the heaviest part of the work—viz., the carriage and spreading of material to the extent of many thousands of tons per 100 ft. of shore frontage.

Again, for every big job, such as the Dover harbour works, where money is no object and the sea is opposed by main force, there are hundreds of minor undertakings where extensive masonry works are out of the question. These undertakings, though often small matters separately, mount up to a very large total when considered collectively. Occasionally we see an extensive coast-line, such as the Holderness coast of Yorkshire, where the erosion, over a frontage of 50 miles has been steadily going on for hundreds of years; but as a rule these marked erosions take place at small bays lying between

rocky headlands or are seen in the pushing back and wasting away of spits or promontories of sand dunes.

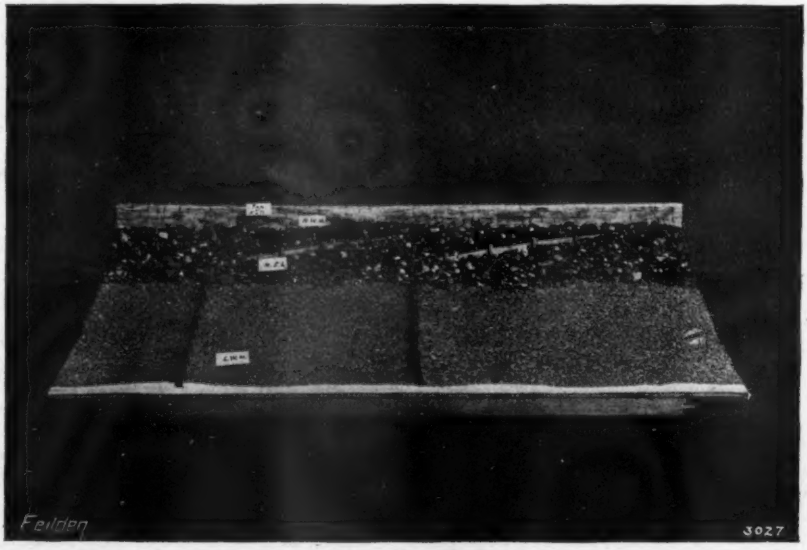
Instances of such minor erosions are to be found at Tramore, Dungarvan Bay, Ardmore, Youghal, Ballycottin Bay, Darrynane, Ballynaskellig Bay and Glenbeigh—all in the counties of Waterford, Cork, and Kerry.

Probably at none of these places would the value of the interests assailed justify an outlay in costly masonry and concrete sea-walls, but at most of them a judicious expenditure on groyning would save the situation.

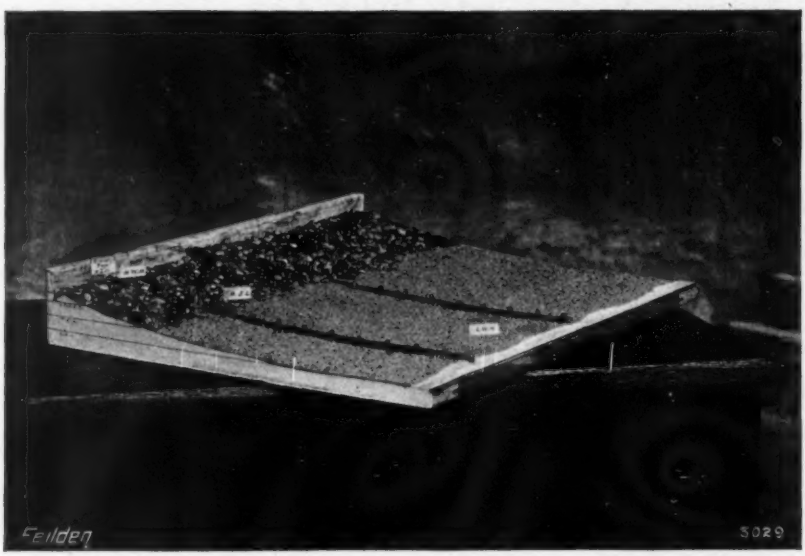
Take Youghal, for example. Here a great many interests were attacked and it was universally felt that an effort should be made to save the pretty little watering-place, which in summer affords such a delightful and accessible holiday resort for the residents in Cork, Limerick, and other towns in the south of Ireland.

About two years ago the author was called in, and advised an immediate application of the Case system. There was a little difficulty at first in getting all the interested parties to agree as to the *proportions* of cost which should be borne by each. After a time, however, the obvious necessity for combined efforts against the common foe brought about unanimous action, and the Great S. & W. Railway, the town of Youghal, the County, the landowners, the householders and the War Office (having an interest in the rifle range) all contributed and the work was started. There was, in this case, a good deal to do. An extensive gap had been made in the beach—over 400 ft. in width—this had to be closed by a stepped wall, a sluice run had to be constructed, and over 8,000 ft. of Case groynes had to be run down to low-water mark. The work is only just finished and has been a complete success, and portions of the shore which had been cut away in deep channels have been completely restored, the accumulation effected in places being from 6 ft. to 8 ft. in depth.

If those interested in Tramore would now give ear to prudent counsel, much



MODEL OF CURVED SLANTING GROYNE.



MODEL OF CURVED SLANTING GROYNE.

valuable land, as well as a most attractive racecourse, might be saved; but it seems likely that procrastination — that worst enemy to economy—will get the upper hand, and that the land will be lost, or only saved at the last moment by an enormously increased and unnecessary outlay.

At Ballycottin Bay the case is a most serious one, as the frontage is considerable —close on three miles—and low-lying land extends inland nearly up to the town of Cloyn. Thousands of acres of good agricultural land are at stake, many roads are threatened, yet no serious effort is made to tackle the question in a practical manner.

At Glenbeigh a difficult problem presents itself. A back-water sea-wall can be satisfactorily repaired at a cost of about £6,000, and by this means 400 acres of the finest land placed again under cultivation. This land might be relied on to return £2 10s. per acre, but the risk is great, on account of the encroachment of the sea on the same land from another quarter. In advising clients in cases like this it is highly desirable to give them the fullest information of the risks they run. In this instance there is very little risk in repairing the old back-water sea embankment—it is a simple engineering undertaking—but there is grave danger of losing all the advantages of the work by direct encroachment of the open sea. A glance at the plan will explain the situation.

It is, of course, for the client to weigh *pros* and *cons*, and decide upon taking or not taking risks, but the engineer who advises a course of action without pointing out the drawbacks and possible dangers as they occur to him at the time and according to his lights, is not acting in an absolutely fair and straightforward manner. It may be disheartening to lose the opportunity of designing and estimating for an interesting bit of work, but it is always better to be as careful of a client's interests as though the property involved belonged to one's-self, and to advise accordingly.

There is a danger, which all enthusiasts should guard against, of becoming so

permanently wedded to one idea or one system that the mind becomes fossilised and incapable of expanding and grasping the fact that useful auxiliaries or other systems are always possible. We cannot stand still for a moment, and one of the chief charms of the civil engineer's life and practice should be the conviction that the laws of Nature are ever capable of fresh adaptations through the ingenuity of fresh intelligences.

Mr. Beard's system of slanting groynes, recently described in *Engineering*, and other papers, appears to be founded on far more scientific principles than are the ordinary high groynes which disfigure the Brighton, Hastings, and St. Leonards shores, but the author is convinced that Mr. Case's system is the better of the two because, as far as his observation has extended, the Case groynes bring up more even shores, and, moreover, catch the travelling material nearer to low water. Before condemning or approving any system it is only fair to bring forward all the scientific arguments possible in the circumstances, and all the proofs which actual experiments can furnish. It is not probable that any one system of groyning will ever be devised which will enable us to dispense *altogether* with such aids as stepped walls, sheet piling or embankments, according to the situation.

With regard to the Case groynes, it has been constantly found necessary to provide some sort of "backing," to prevent the encroachment of the sea and the driving inland of sand and shingle *during the process of building the shore up to its proper inclined surface*, and to meet this want Messrs. Case & Gray designed a very excellent stepped wall which is probably the best form of wall to use with these groynes.

But there are occasions when a wall may possibly be too expensive, and the author has suggested a form of curved slanting groynes to be used in conjunction with the low groynes. These slanting groynes were suggested by some practical experiments recently made at Glenbeigh, Co. Kerry, and are recommended *in certain*

MODEL OF CURVED SLANTING GROYNE.

situations. The illustrations, taken from the author's model, will indicate the general idea and intention of these groynes, which may be looked upon as safe auxiliaries to the low groynes.

The action of these slanting groynes differs from the action of the Case groynes, which act on the lateral currents by slowing them down, and causing a deposit of material which would otherwise pass away. The author's curved slanting groynes rely almost entirely on the agency of the waves, and trap and detain shingle which is thrown over from windward to lee.

It is instructive to spend a few hours in watching the result of a dead on-shore gale on slanting groynes. If there is much travelling beach it will be observed that the shingle — often consisting of heavy stones—is bodily carried over the top of the groynes and retained on the lee side, where it is required for the foundation of the "full." This retention is due to the circumstance that the slanting groynes, running diagonally up the beach, are inclined at a *much flatter gradient than those groynes running at right angles to the coast-line*, and, therefore, the retreating volume of water which causes the scour has less power to carry away the deposited shingle. On the same principle a very rapid mountain torrent will carry down huge boulders, which would rest peacefully for ever at the bottom of the same river when it emerges into flatter lands, and winds amongst the lower valleys.

The slanting groynes recommended form a continuation of the Case groynes, from mean sea level up to high-water mark, and they are constructed on much the same simple principles, but the timber has to be of heavier scantling because of the pounding action of the sea in rough weather. Here it may be observed that, in selecting our timber we must be guided by the position it is to occupy on the shore as well as by the size and quality of the shingle composing the beach.

Experience shows that, when acting on timber — especially vertical piles — the sawing action of sandstones is worse than that of rounded flints, though the latter may have a more erosive effect on the faces of sea walls. Where piles have been driven anywhere in the neighbourhood of high-water mark, in localities where there is a heavy travel of beach, it will often pay to protect the *windward piles*, at the portions where they are most subjected to this sawing action of the shingle, by angle iron, or, better still, by nailing on planks, which can be renewed when worn through. This may seem a small point, but it is one which should receive attention. The life of the windward piles may be doubled or trebled by attention to this detail, and much expense saved in repairs and general maintenance.

The construction and application of these slanting groynes were very fully described in a paper read to the Institution of Civil Engineers in Ireland last January, and shortly afterwards the author received communications from gentlemen who had read his paper objecting to these groynes as being erected at high-water mark, and therefore bound to create scour. The arguments in the objections were not of a very scientific nature, and amounted to this:—"The slanting groynes are near high-water mark, and therefore must be condemned."

Feeling that he had not made his meaning sufficiently clear, the author then prepared a second short paper, in which he endeavoured still further to explain and elucidate the question. This paper was read to the Institution in February last, and the following paragraphs are here quoted:—

"It will be conceded that there must always be *some* obstruction at high-water mark. The line of demarcation or boundary between the sea and land always exists, whether in the form of a sand-dune, a shingle bank, esplanade wall, line of sheet piling, or stepped breastwork wall.

"If, therefore, it can be shown that a particular form of high-water protection answers the purpose of collecting and retaining shingle in certain situations, there can be no reason in objecting to it merely on account of its name. The fact is that, as strong advocates of the Case system of low groynes and equally strong opponents of the ordinarily accepted high groynes, as erected at Hastings, Brighton,

and elsewhere, we are, not perhaps unnaturally, apt to regard with disfavour anything in the nature of a groyne anywhere near high-water mark.

"As regards the form of slanting groynes suggested by the author, the idea was to use them as accumulators or traps for the shingle at points on the shore where the Case groynes do not reach, but which, nevertheless, have to be protected. The elliptical concrete wall, or similarly designed embankment of timber, has been successfully applied in conjunction with the Case groynes, but a close examination will reveal the fact that the slanting groyne is in reality a modification of the stepped wall, each step of which touches a point on the curved and slanting groyne. The protection afforded by the slanting groyne may not be so effective as that given by the stepped wall, but where there is a heavy travel of beach and a long line of coast to be protected, and limited means at the disposal of the engineer, it is suggested as a valuable auxiliary.

"The idea of using slanting groynes is not by any means new, so that the author disclaims any title to originality under this heading. There appears, however, to be some indication of novelty in the idea of a curved groyne gradually working up from a low groyne until it has reached the limit of high-water mark; and the advantages of such a groyne may be best worked out theoretically by first of all considering some of the more important phenomena and conditions obtaining on the generality of shores.

"It will be at once conceded that the steepest line of descent on any shore is found by taking a section of the shore at right angles to the coast-line. It follows, then, that, when originally constructed, all groynes running at right angles to the coast-line have, on either side, the steepest possible gradient on that portion of the shore.

"It will probably be also admitted that, if the groyne be run out in any other direction whatever on either side, the gradient will be less steep, because the line will run diagonally up and down the beach. The maximum of steepness is shown by the sectional line at right angles to the coast-line, all other lines gradually diminishing in steepness from 0° up to 90°, when the minimum is reached at dead level with the original point of starting.

"It can also be easily proved by elementary mechanics that bodies more readily slide down steep inclines than they do down inclines which are not so steep, and that, where the action of water is concerned, heavy boulders and shingle of all sizes are readily moved in rapid rivers, and that they are not moved at all, or only very slightly, in sluggish rivers.

"Following up this line of reasoning, we arrive in a very few steps at the conclusion that the important point is *the steepness of the gradient*, and that, where scouring action is to take place, it will, *ceteris paribus*, be worse on the lee side of those groynes which run down the steepest gradient.

"It can also be demonstrated that the less steep the gradient the longer it takes for the water to run off by filtration or percolation or by running down the lee side of the groyne, and that, therefore, material of all kinds has a better chance of being retained where it is wanted.

"It can also be readily shown that those proposed groynes (being constructed as described in the author's recent paper and read to the Institution on January 9th) are not of the nature of solid immovable structures, and can always be lowered or raised to meet *the circumstances of the case at any moment*, and that, therefore, they must not be included in the list of dangerous solid obstacles at high-water mark.

"To turn to the practical aspect of the matter. In 1896, during the author's absence from England, a couple of box groynes were run out at right angles to the shore-line at a portion of the Glenbeigh coast, where the cliffs were undergoing very rapid erosion. These groynes not only failed to collect material but caused the formation of bays or indentations of the cliff on either side.

"Soon after this Mr. H. M. H. Collier, A.M.Inst.C.E., put down a few slanting groynes composed of railway sleepers driven in as sheet piling. And this may

be regarded as the first really scientific effort made to protect this portion of the shore. Owing to the inadequacy of funds at his disposal, and the very slender nature of the work, these groynes were gradually swept away by storms, but not before they had given very marked indications of success.

"In 1898 the author erected three slanting groynes of a more solid form of construction (shortly described in his paper of January 9th). There was practically no shingle at all at the toe of the cliff when these groynes were completed in the summer of 1898. Repeated observation showed that shingle was continually thrown over and retained on the lee side of these three groynes, and that the improvement has been continued, and is still continued, is clearly demonstrated by the existence of a heavy bank of shingle effectually protecting the toe of the cliff, which is now grassing over in many places. This shingle was not there in 1898; it is there to-day, and this actual fact should go far towards backing up the author's opinion that slanting groynes will, in certain situations, catch and satisfactorily retain shingle.

"We have to admit that it is common sense, backed by technical knowledge and experience, which carries us through the most serious engineering difficulties.

"In the case before us we have a set of slanting groynes of very rough and ready construction, and most imperfect in design, and yet it is shown that they have been instrumental in safeguarding a portion of the coast.

"Common sense points to the probability that similar groynes more scientifically designed will be even more effective, and the author in designing these partly curved slanting groynes has kept carefully before him the points which have seemed of greatest importance—viz.:—Trapping and retaining of shingle; reduction of scouring action; rapidity of lowering and heightening; simplicity of design and economy.

"No doubt it is highly important for specialists in sea work to be ever on the alert, as there are few branches of civil engineering where disappointment so frequently follows the expenditure of money as it does in the case of foreshore protection.

"If we build a bridge, or a retaining wall, or a house, there is a reasonable hope that, given immunity from earthquakes, waterspouts, or foreign invasion, the work will at any rate outlive the present generation. But with sea-coast protection works this is by no means the case, for the engineer, often cramped in his designs and estimates through the limited means at the disposal of his clients, finds he has to fight a most relentless foe with very indifferent weapons. In short, he has not to carry out what he feels certain is necessary to insure protection, but to make the best job he can of it with very inadequate means.

"The author has been for so long advocating the claims of the 'Case System,' as being better than any other, that it is hardly necessary for him to disclaim any intention of supplanting that system, which seems to him to stand alone in its originality of conception. What he wishes to do—and his humble efforts have been entirely in this direction, and with this object in view—is to think out and devise some method which, without clashing in any way with his late friend's invention, may be profitably used as an auxiliary in certain situations."

Some advantages of a combination of low groynes with slanting groynes appear to be:—

1. The diversion shorewards of material travelling between low water and and mean sea level by the low groynes, this action depending mainly on lateral currents.
2. The catching and retaining of beach by the slanting groynes, which need never cause scour because they can be regulated to meet the requirements of the case almost as easily as the low groynes.
3. The accumulation of beach takes place both on the windward and lee sides of the slanting groynes.
4. The slanting portions of the groynes may in many cases take the place of walls.

5. The cost of the Case groynes is about 10*s.* 6*d.* per foot run, and the slanting groynes, of which, in nearly every instance, short lengths would be required, would be from £1 to £2 per foot run.

To facilitate the erection of low groynes where the insertion of horizontal timbers through the body of the piles is required, the author has devised a form of laminated pile, for which provisional protection has been granted by the Patent Office. This pile is constructed of two battens, of the same scantling, which are kept apart by a fixed distance piece at the lower end, and by a removable distance piece fitting entirely the remaining space between the two battens. The lower end of such laminated pile may be shod with iron in any convenient manner, and the upper parts are clamped together by one or more wrought-iron embracing clamps according to the length and scantling of the timbers, or may be temporarily held together by through bolts, or other means.

The top of the pile is covered with a tight fitting, wrought-iron cap, which may have a central hole in its upper face for the insertion of a guiding bar for the driving weight of a ringing engine.

The pile having been driven to the required depth, the iron cap, clamps, or temporary through bolts are removed, and the central batten or plank is then withdrawn, for which purpose a hole for a bar may be provided in the said plank. A space is thus left through the body of the pile for the insertion of horizontal planks placed edge to edge to form a low continuous groyne.

The movable plank, which should be made of durable timber, is now available, with the same cap and clamps, for adaptation to another laminated pile which is clamped, capped, and driven, as before. The arrangement forms a cheap and expeditious means for driving short piles, adapted thereafter to receive and hold horizontal planks to form a low groyne.

R. G. Allanson-Winn.

The Duff Gas Producer and Water-Tube Boilers at the Glasgow Exhibition

By F. J. ROWAN, AM.INST.C.E., and C. HALLIDAY, WHIT.SCH.

THE stress of competition in manufacture and the prospect which has been revealed and frequently emphasised in recent times, of higher-priced coal supplies in the future, have awakened manufacturers of all kinds to a greater interest in possible methods of economising in their work than they have cared to be credited with in past years.

PRODUCER.

For this reason such a means of economising fuel as the Duff Gas-producer, which was shown in operation by Messrs. W. F. Mason, Ltd., of Manchester attracted wide-spread attention. Although, in this Exhibition it was used only in connection with the process of steam generating, yet it is well-known that the question of the employment of producer gas affects every industry in which fuel is used.

The Duff gas-producer was erected on the space of ground just outside the boiler-house of the Exhibition, between the south end of the machinery hall and the covered way leading to Partick Central Railway Station. It stood on the ground level; the producer top, and platform, being on a level with the gallery running round the boiler-house inside. There were no means of bringing the railway coal trucks alongside the producer platform, and consequently the coal supplies had to be tipped on the ground level, from which they were raised to the platform by an elevator of the bucket-ladder type, made by Messrs. Graham, Morton & Co., Ltd., of Leeds, which was worked by a 3 h.p. electro-motor supplied by Messrs. Ernest Scott and Mountain, Ltd. The whole of the apparatus formed a complete installation of which a general view is given in the photograph which we reproduce.

It will be seen from the two vertical sections at right angles to one another, which are represented in Fig. 1, that this gas-producer consists of a shell casing of riveted boiler plate with brickwork inside forming the walls and roof, and a brick water trough running across the base of

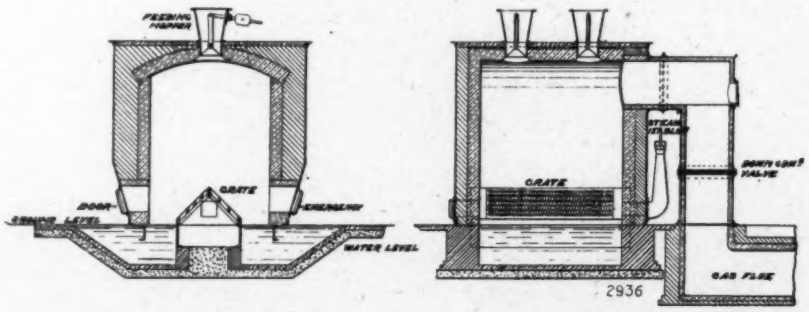


FIG. 1.—VERTICAL SECTIONS OF DUFF'S GAS PRODUCER TAKEN AT RIGHT ANGLES TO ONE ANOTHER.

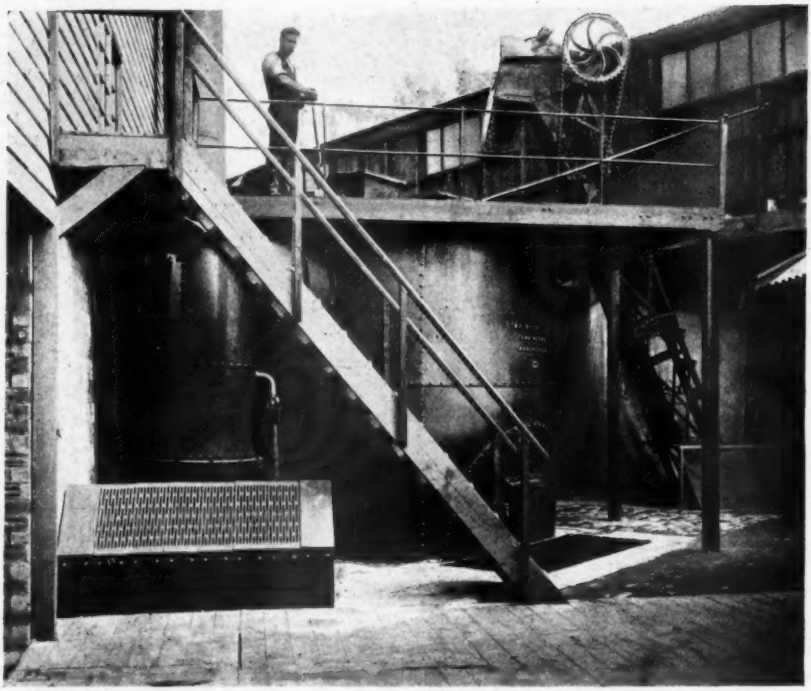


FIG. 2.—THE DUFF GAS PRODUCER AT THE GLASGOW EXHIBITION USED FOR FIRING THE STIRLING BOILER.

the shell and divided in the centre by an angled grate which reaches across the entire width of the producer inside. On the top, which is supported by a brick arch, there are two cast-iron filling hoppers provided with bell-cones and levers for lowering charges, and with sliding lids or doors above to prevent escape of gas when the bell-cones are lowered.

The iron casing of the producer shown is 12 ft. diameter and 11 ft. 6 ins. high. It is of cylindrical shape, but slightly flattened at the bottom on the two sides on which the water trough extends. This enables a smaller water trough to be used than would be necessary if the full diameter of the casing projected, and gives opportunity for putting on small emergency doors when these are wanted.

The brick lining is built to form a fuel chamber of an oblong shape with the corners rounded off, as this suits the form of the grate as giving an equal depth or thickness of fuel on both sides of it. The clear fuel space inside the brickwork measures 7 ft. 6 ins. by 9 ft., the latter being measured along the grate. The water trough measures 17 ft. long at ground level by 9 ft. broad; but it is, as the sections show, divided in the centre by the brick seating for the grate.

This grate is the kernel of Mr. Duff's invention, and has several important features in connection with gas production into which we cannot enter in this article. Suffice it to say here that it gives a command of gas production for ordinary purposes that is pretty nearly perfect, enabling any quality of coal to be successfully

treated, and abolishing trouble from clinker and the need of heavy labour in pokering. This particular specimen of the Duff grate is 4 ft. broad at the bottom and 2 ft. 6 ins. high to the apex of the angle formed by the sloping sides. It stretches right across the fuel space, the ends being embedded in the brickwork, but the perforated portion forming the great area is 8 ft. long, there being in all 40 sq. ft. of grate area. The sloping sides are formed by perforated cast-iron grids which are set at an angle of 45 degs., there being six or eight such grids in the length, so that any portion of the grate could be quickly renewed. Opposite one end of the grate the producer shell is pierced by the pipe which delivers the steam and air blast from the steam jet blower which is shown, and opposite the other end there may be a small door for the removal of any ash which may find its way through the small perforations of the grate, or for inspection of the interior of the grate. In the foreground of the photograph will be seen one of the grates placed there for inspection. The casing rests partly on the two side walls of the water trough and partly on the two short channel iron beams which stretch across the trough and, by dipping into the water, form the water seal to the producer, preventing the escape of blast or gas in that direction. In addition to the two hoppers, the roof or top of the producer is pierced by eight poker holes, arranged four on each side alongside the hoppers, by means of which all the poking work required by this producer is carried out.

The gas is led off by a branch and down-corner, 2 ft. 9 ins. diameter inside the brick lining, with a damper or slide valve formed of iron plate in the down-corner, from which a brick gas flue, 1 ft. 8 ins. broad and 1 ft. 10 ins. high to crown of arch, leads the gas to the front of the Stirling boiler, where it passes through a mushroom valve 18 ins. in diameter.

This producer is of the size capable of gasifying 15 cwts. of coal slack per hour, but as it was connected to only one boiler in the Exhibition, it was not called upon to exceed a third of that rate. A smaller size might have been erected, but such would not have been so generally useful, and we presume this installation will be erected elsewhere after the close of the Exhibition.

ELEVATOR.

The elevator for handling the coal for the producer was made by Messrs. Graham, Morton & Co. to their standard design, 25 ft. between centres of sprocket wheels top and bottom, the lower end being placed in a box or well sunk in the ground and the top rising over the producer platform and delivering into a shoot.

The elevator consists of a cast-iron boot provided with adjustable sliding blocks, which support the bottom shaft and sprocket wheel and provide for the necessary adjustment of the chain. Attached to this boot is a wrought-iron hopper, provided with a grid or sieve of about 2-in. mesh to prevent excessively large lumps of coal passing into the elevator buckets. This grid is arranged to be on the ground level, so that the coal falls into the hopper when tipped on to it.

The framing of the elevator consists of four angle iron runners lined with greenheart wood for reducing the noise of working, the bracing of the elevator forming practically a box girder throughout its length.

The buckets are protected on the return side by a wrought-iron or steel casing, which will be seen in the illustration. These buckets are made of seamless steel and are attached, with their guide bars, to an endless strand of steel roller chain, which is firmly stretched over the top and bottom sprocket wheels. The chain runs at about 50 ft. per minute, each bucket holding a few pounds of coal. The top of the elevator is arranged to discharge the coal on the producer platform, and the various working parts are provided with lubricators.

The driving was carried out by a 3 b.h.p. electro-motor, made, with its switch and starting resistance, by Messrs. Ernest Scott & Mountain, Ltd. This connects by one of R. & J. Dick's belts to the large pulley of a countershaft, on the other end of

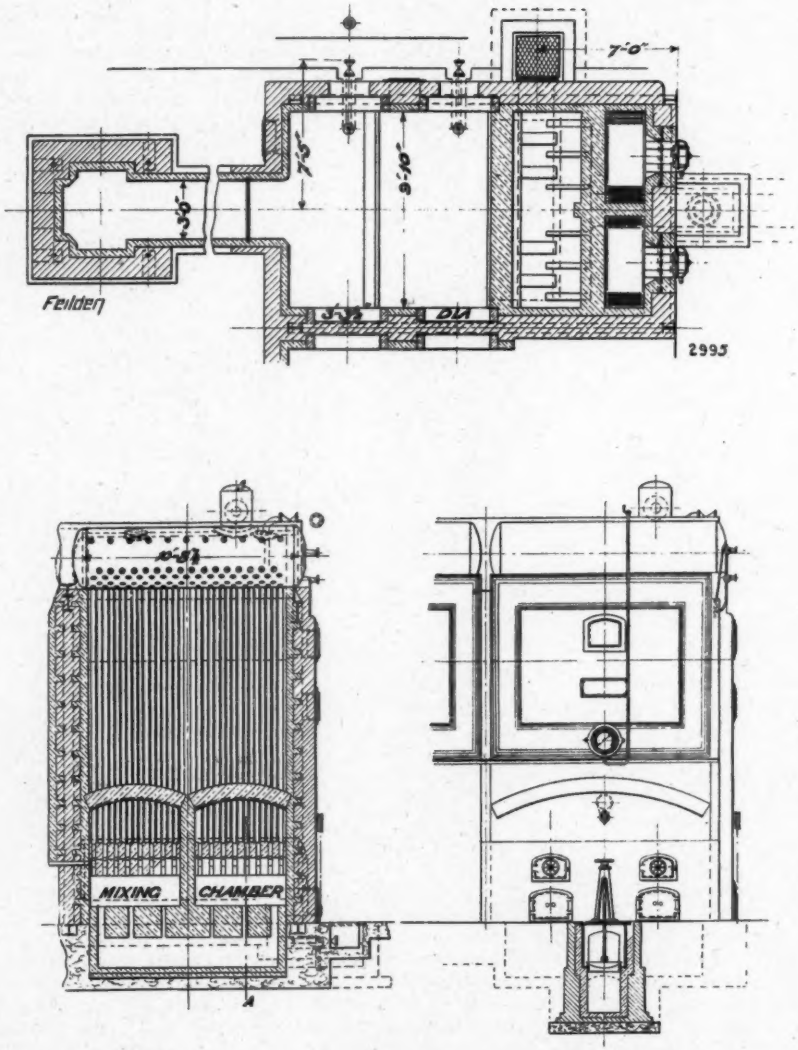


FIG. 3.—DETAILS OF THE GAS-FIRED STIRLING BOILER AT THE GLASGOW EXHIBITION.

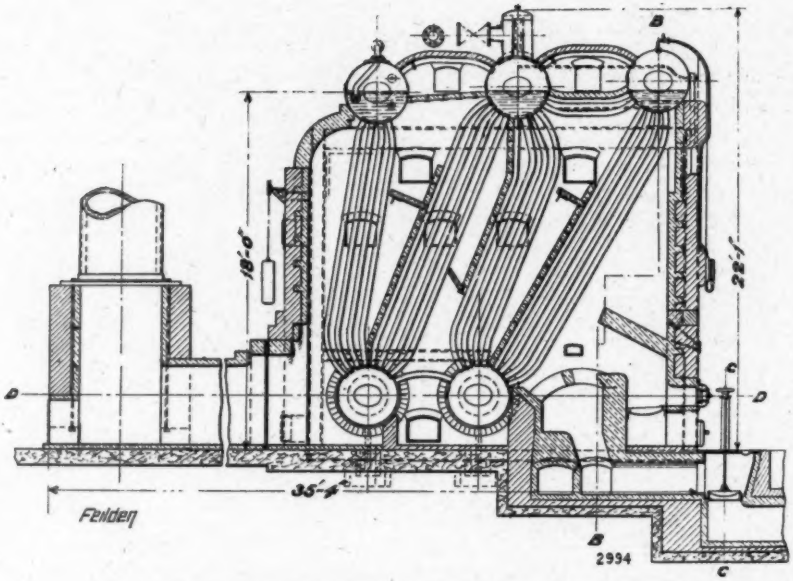


FIG. 4.—DETAILS OF THE GAS-FIRED STIRLING BOILER AT THE GLASGOW EXHIBITION

which is a small chain pulley. The endless chain passes over this pulley and a large wheel on the top shaft of the elevator.

BOILERS.

There were two Stirling water-tube boilers in the Exhibition shown by the Stirling Boiler Co., Ltd., but only one of them was fired by gas, the other having a Vicars mechanical stoker. We reproduce a photograph of the front of the boilers, from which the neat and clean appearance of the gas-fired boiler can be observed.

The Stirling boiler is, as is now well known, composed of nearly vertical water tubes, connected at the top and bottom ends to horizontal cylindrical drums, of which two are under the fire grate level, and are used as water reservoirs, and three are at the top of the boiler, and are used for water and steam.

In the boiler at the Glasgow Exhibition, the vertical tubes are $3\frac{1}{2}$ ins. outside diameter, there being 16 rows of these tubes, 10 in each row, and the drums are 3 ft. diameter inside. The four front rows of tubes nearest the fire have more inclination than the others, and the effect of this is to form a large and lofty combustion space, which is a good feature of the design. From Fig. 4 it will be observed that by means of pillars and beams the boiler is suspended from the top drums, thus leaving the vertical tubes free to expand downwards.

Figs. 3 and 4 show the arrangement of furnace and casing for the gas-fired boiler. The gas, after passing through the mush-room valve, enters by a short fore-and-aft flue into the centre of a transverse flue, from which it escapes upwards by a series of slots or passages in the arched roof and superincumbent brickwork, issuing into a mixing chamber 3 ft. broad by 2 ft 5 ins. high, and extending right across the breadth of the boiler. Here it meets the streams of air from a transverse flue, similar to the gas flue, with openings in its roof, which occur in alternate spaces to those of the gas flue. The air from the boiler room is admitted to the air-flue by an iron grating which covers a projection

of the air-flue carried out beyond the side wall of the boiler casing. The air is practically cold on entering the flue, and is only slightly warmed by radiation from the brickwork on its passage along and up to the mixing chamber, but from the openings in the roof of this latter, streams of clean flame without smoke issue upwards and finally turn in amongst the first four rows of water-tubes. A small sight door is placed in the side wall just above the arch of the mixing chamber, and this would in ordinary circumstances be available for lighting the gas on its first admission to the boiler combustion chamber. In the case of the boiler in the Exhibition, however, a small grate has been formed close to the front wall in the space above the short gas-flue, from the valve to the transverse flue; and there are two fire-doors giving access to this grate, on which a small fire of coals is sometimes kept burning. This small fire also serves to get up sufficient steam pressure to start the steam jet of the producer blower when commencing a week's work after the boilers have been blown off. This fireplace is, however, not an advantage to the gas-firing arrangements on account of its occupying valuable combustion space and causing the exit openings from the mixing chamber for the gas and air to be too close to the water-tubes, and also on account of arched roof or deflector arch which covers this fire place and still further confines the combustion space for the gas flame, besides deflecting it on to the water tubes at too low a point. The full benefit of the combustion space which should be available with this type of boiler is therefore not reaped, and it would be an advantage to the gas firing of such boilers if other arrangements were made by which that space was completely utilised. Although many of the advantages that are inherent in gas firing as applied to boilers are independent of a supply of heated air, yet there is no doubt that if the air for combustion were heated by means of the waste heat in the gases a more economical result would be obtained than can be expected in the case of combustion with cold air We cannot here go into the reasons for this, but it will commend itself to those who have studied the question of gas firing. It is certainly most beneficial to a boiler that after the fire is once lighted there is no alternation of high and low temperature such as is produced by the operations of coal firing, and that no smoke or soot is formed to the detriment of the heating surface. A steady stream of clear bright flame is continuously kept in contact with

FIG. 5.
EXTERNAL VIEW OF STIRLING BOILERS AT THE GLASGOW EXHIBITION.

the generating surfaces, and the maximum effect can be produced continuously.

The rapidity with which the fire can be put out, without any such operation as that of drawing fires, in case of need is also a point of considerable importance in favour of gas firing which has been illustrated in the case of this boiler.

The stoking of the producer is a much less laborious affair than the stoking of a boiler with solid fuel, especially where several boilers are worked together from a common gas supply. In this case, as we have remarked, however, the producer capacity and boiler requirements are disproportionate.

Comparative tests with the Exhibition boilers were made, but up to the present the results have not been made known. There have, however, been tests made at an ironworks in Stockton-on-Tees, on the firing of a Stirling boiler with producer gas from a Duff producer using a mixture of puddling furnace breeze and forge slack, the results of which were very satisfactory.

THE BABCOCK AND WILCOX BOILERS.

We give an illustration of the boilers exhibited by Messrs. Babcock & Wilcox at the Exhibition. There are two patent water-tube steam boilers of the land type, each possessing 5,137 sq. ft. of heating surface, and constructed for a working pressure of 160 lbs. per sq. in. The two boilers were set together in one battery or nest.

Each boiler consists of 18 sections of tubes, each section being made up of 12 tubes, with an additional row of tubes which form what is known as the Patent Scotch furnace. The tubes are 4 ins. in diameter and 18 ft. in length, and they are expanded at the ends into headers.

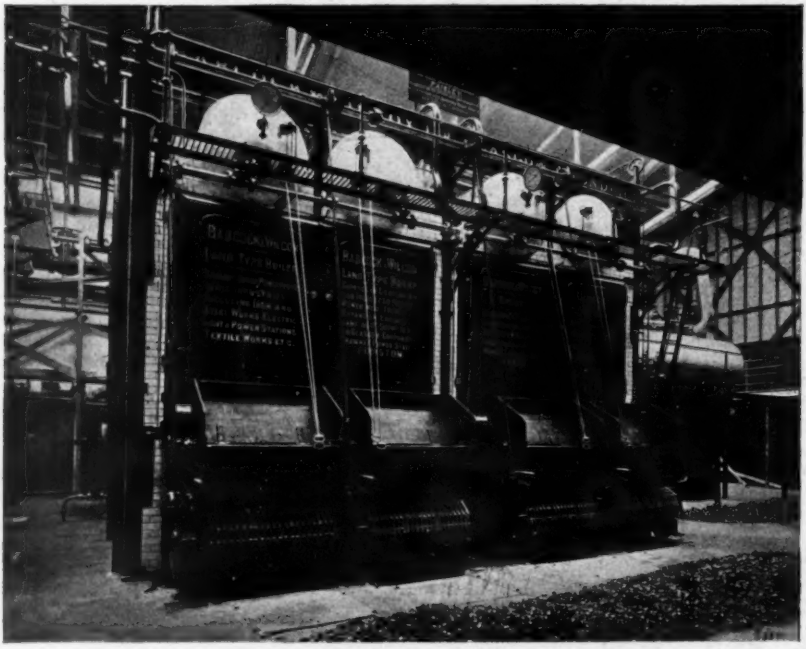


FIG. 6.– EXTERNAL VIEW OF THE BABCOCK AND WILCOX BOILER AT THE GLASGOW EXHIBITION.

The headers are connected at the front and rear to two steam and water drums, 48 ins. in diameter.

As seen from the figure, the end connections, or headers, are in one piece for each vertical row of tubes, and are of such form that the tubes are staggered, or so placed that each row covers over the spaces in the previous row. The holes for the tubes are made with a taper, and the tubes expanded into them. These sections are connected with the steam-drum and with the mud-drum, also by short tubes expanded into bored holes. There are hand-hole doors opposite the end of each tube, and the joint surfaces are milled and the joint made by a special three-ply ring of asbestos.

The steam and water drums are made of flange iron or steel and double riveted, and they are tested 50 per cent. above the working pressure. The boiler is suspended from wrought-iron girders resting on iron columns. This avoids any straining between it and the enclosing walls.

The fire is under the front and higher end of the tubes, and the hot gases pass up between the tubes into a combustion chamber under the steam and water drum; from thence they pass down between the tubes, then once again up through the spaces between the tubes, and away to the chimney. The water in the tubes, when heated, flows towards the higher end, and then up the headers into the drum. Water descends through the connections to the lower headers, and from thence to the tubes. And so a continuous circulation in one direction is maintained.

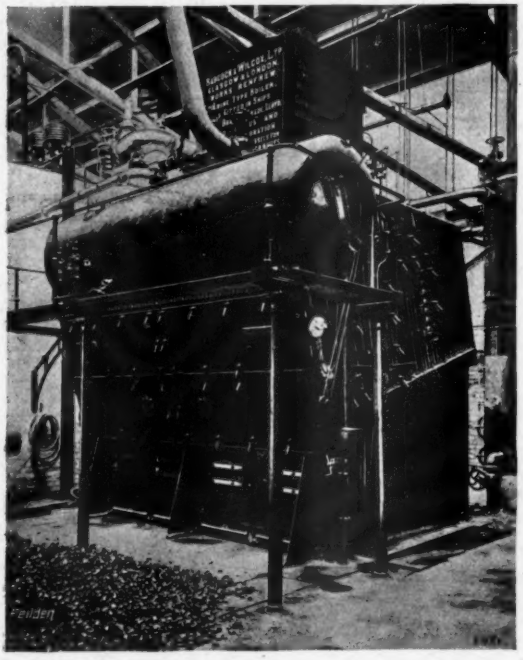


FIG. 7.
MARINE TYPE BABCOCK AND WILCOX BOILER AT GLASGOW EXHIBITION.

Many of the land boilers are fitted with steam superheaters. In this way provision is made against cylinder combustion, which is so great a source of waste in steam-engine economy. In some non-condensing engines, this waste has reached as high as 35 per cent. to 40 per cent. of the total steam used. Superheating the steam has the further advantage of evaporating any water which may be contained in the steam in any way.

In designing this arrangement of superheater the following points have been kept in sight. It has been placed in a position where a suitable temperature is available. It is not played on by fire gases, nor has it been placed between the boiler and the chimney and acted on by the low-temperature exhaust gases. It has been placed, as shown in figure, at the top of the tubes, and is played on by the gases after they have passed through the tubes and have lost the higher furnace temperature but still retain a considerable temperature.

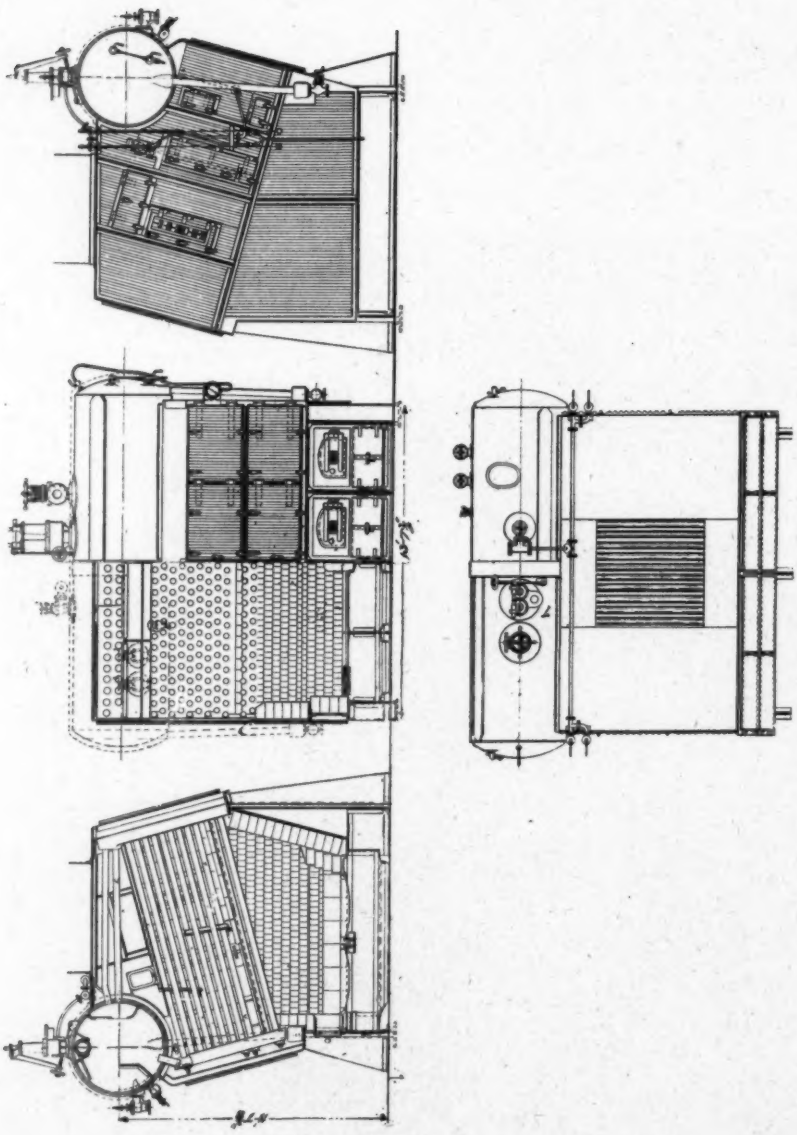


FIG. 8.—DETAILS OF THE MARINE TYPE BABCOCK AND WILCOX BOILER AT THE GLASGOW EXHIBITION.

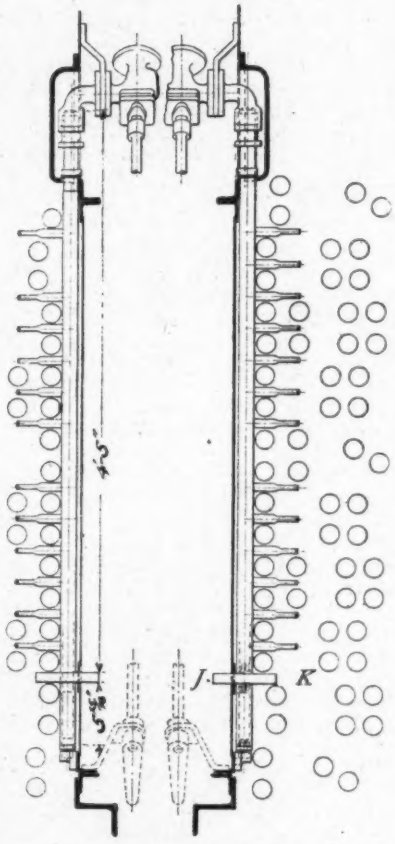


FIG. 9.—DETAILS OF SOOT-CLEANING ARRANGEMENT, BABCOCK AND WILCOX BOILER.

An arrangement has been added which allows it to be flooded when steam has not yet been raised or is passing through it, to carry away the heat supplied by the furnace gases.

The superheater consists, as is seen in Fig. 11 of two horizontal boxes made of mild steel—an upper one *F* and a lower cross-box *H*. These are connected by U tubes *G* of 1½ ins. diameter in groups of four, with their ends expanded into the boxes *F*, *H* as shown. Hand-holes, to allow of access to the ends of the tubes, are fitted in the opposite walls of the boxes.

There are two steam collectors *G* in each drum, and these are connected to the upper box by two pipes. The lower box is connected at the ends by two vertical pipes to a crosspiece *K* on the top of the drum. The main steam pipe is joined to the crosspiece, and the stop-valve *L* is also connected to the same at the top.

The flooding arrangement of pipes *O* is connected to the bottom of the lower box *H*, and is connected to a three-way cock *N* at the back of the boiler. From this three-way cock a pipe *S* leads to the steam drum into the water space. When it is required to flood the superheater, the blow-off cock at *N* is shut and the cock at the drum *R* opened; and when steam is to be superheated, the cock at the drum *R* is shut and the blow-off cock opened until all the water is discharged from the superheater.

There is also an equalising pipe *Y* on the top of the steam drum joining the drum steam space with the stop-valve. By this means steam is allowed to mix with the superheated steam and so reduce the superheat if necessary.

The marine type of boiler which is exhibited has a special interest at the present time, as it has been the subject of discussion in the press—it has been under the earnest consideration and trial of many of the navies of the nations—it has been the subject of questions in Parliament, and it is one of those recommended for trial in H.M. fleet. Orders have already been given for boilers of this type to be fitted in the second-class cruiser *Hermes*, in the battleship *Queen*, the second-class cruiser *Challenger* and the first-class cruiser *Cornwall*, and trials have been made of it in the gunboat *Sheldrake* and in the sloop *Espiegle*, and a further order has been given for the *Odin*.

Considerable experience has been gained from its use in the navy of the United States and in the Wilson line of steamers.

The construction of the marine type of boiler is on the same lines as the land boiler and is shown in Figs. 7 and 8. There are two designs, one having medium-sized tubes, the other large tubes. It is

constructed wholly of wrought steel. The tubes are inclined at an angle of 15 deg. to the horizontal. The drum extends across the front of the boiler and is connected to the upper ends of the front headers by short tubes. The back headers are connected to the drum by horizontal tubes. There is a blow off or sediment box placed across the bottom of the front headers, and connected to them by short tubes or nipples and through this box the boiler can be completely drained. Baffle plates are situated in the steam drum, and the steam and circulating water are directed against these, which cause the water to be thrown downwards, while the steam separates and passes round the ends of the baffle plates to the steam space, from which it is taken by a perforated dry pipe to the stop valve.

There is a continuous circulation in one direction, and this gives the boiler an equal temperature throughout. Wash plates are also situated in the steam drum to prevent under movement of the water when the ship is rolling.

The tubes are of seamless steel. Doors are fitted opposite each tube to provide access to their ends for examination or removal. The joint of the door is made on the inside of the heater by an asbestos wire-woven gastrel. For small tubes the openings are closed by plugs with coned joints drawn up to their seats with faced cap nuts, thus making metal to metal joints.

An important ship which has been recently fitted with these boilers is the U.S. cruiser *Cincinnati*. Tests were made on one of these boilers from June 15th to 22nd, 1900, at the works of the builders, Elizabeth Port, N.J. The total heating surface was 2,640 sq. ft.; total firebar surface 63·25 sq. ft. The tubes were 2 ins. diameter, except the bottom row, which were 4 ins. diameter. Working pressure was 215 lbs. per sq. in. The coal used was Pocahontas, from Flat Top Mine. The moisture was determined by a Barrus calorimeter. The temperature of the water in the boilers when fires were lighted was 72 degs. Fahr. In 5 minutes after lighting fires steam was formed, in 10 minutes it stood at 85 lbs. pressure, and in 12 minutes 40 seconds the valves were on the point of blowing off at 215 lbs. per sq. in. The following is the result of trial on June 22nd:—

The duration of test was 3⅓ hours average pressure, 210·8 draught, 1·48 in. at chimney, and at ash-pit 1·685 ins.

Temperatures: External air, 90·7 degs.; fire-room, 117; steam, 391·9; feed-water entering boiler, 99·7; escaping gases, less than 900 degs. Fahr.

Fuel: Moisture in coal, ·88 per cent.; refuse, 8·45 per cent.; consumption of dry coal per sq. ft. of heating surface, 1·419; combustible per hour per sq. ft. of heating surface, 1·299 lbs.; moisture in steam, 0.

Evaporation per sq. ft. of heating surface, 13·67 lbs.; equivalent evaporation from and at 212 degs. per lb. of dry coal, 9·63 lbs.; ditto per lb. of combustible, 10·52 lbs. The tests were made by U.S. officials.

One of the great troubles encountered with water-tube boilers at sea is the collection of soot and dirt on the surfaces of the tubes, reducing the efficiency of transmission of heat. This becomes so very bad when the voyage is over twenty-four

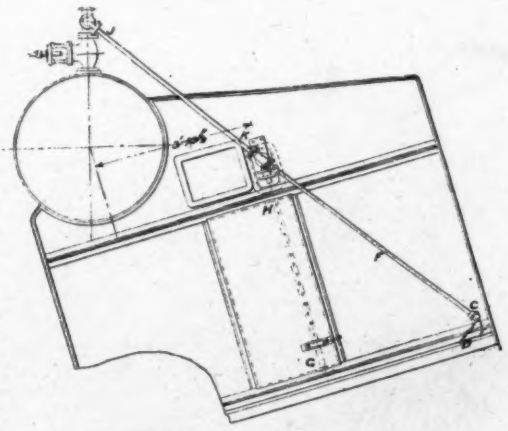


FIG. 10.—DETAILS OF SOOT-CLEANING ARRANGEMENT, BABCOCK AND WILCOX BOILER.

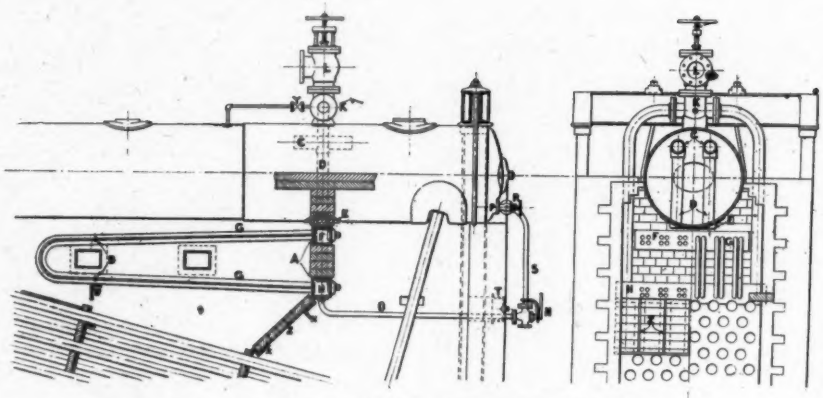
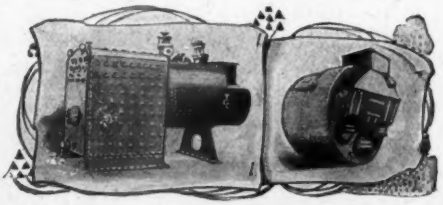


FIG. 11.—DETAILS OF SUPER-HEATED BABCOCK AND WILCOX BOILER.

hours that it has been proposed to fit scrapers on the boilers in the same way as they are used in Green's economiser. Messrs. Babcock & Wilcox use a soot-cleaning arrangement, which was fitted on the marine boiler of the Exhibition. It is shown in Fig. 9 and at *G H* in Fig. 10, in the side elevation of the first boiler. It consists of a 1½-in. pipe fitted alongside of the boiler, and has a number of nipples along its length, so spaced that they point between the rows of tubes of the boiler, Fig. 9. The pipe can be made to turn through an angle of 120 degs. so that the steam has a considerable radius of action. The pipe receives the steam through pipe *J K*, Fig. 10, which is attached to the steam-pipe above the stop-valve. The nipples command the whole area of space between the rows of tubes, and the effect of cleaning every watch is very marked.

Jno. Geo. Rowan

Geo. Halliday



Stocktaking

By A. HAMILTON CHURCH.

Considering the vital importance from a commercial pointof view of the series of operations comprised under the term "Stocktaking," it is a matter for some surprise to observe the hasty and perfunctory manner in which this valuation of assets is frequently carried out.

Many principals and directors do not in fact appear to realise that the advantages of a first-class and modern system of works accountancy are rendered wholly nugatory, and the system itself worse than useless, because misleading, by reason of the inexact and amateurish manner in which "stock" is taken at the end of a financial period. Yet a moment's reflection will show that every balance-sheet, and hence profits or dividends, may, when business is cut fine, be actually falsified and made illusory by comparatively small and easily-made errors in connection with the valuation of such items as plant, tools, fixtures, and work in progress, even where, as is usually the case, the values of raw materials and finished goods are correctly set out.

It must be confessed that in an establishment comprising many departments and a variety of operations the scientific as apart from the casual determination of values is no easy matter, and demands not merely the systematic method of the accountant but also the practical experience of the technicist to be wholly satisfactory. It is precisely because this is the case and that their determination lies between the spheres of interest of two not always inhostile powers, that precision is so rarely to be found.

In the present article it is proposed to discuss some of the more obvious precautions to be taken when making a valuation of assets in places where no scientific method of dealing *in detail* with the increases and decreases of such assets has as yet been worked out.

Except in works organised on very modern lines, such as the "Slater-Lewis" system, the figures obtained at stocktaking are then known for the first time, *i.e.* there is no foreknowledge of what they *should* be. This involves, necessarily, that when found there is practically no check, or at least no arithmetical or balance check of their accuracy. There is, of course, within wide limits, the check of "judgment," but this is a most vague and unsatisfactory element and liable to be warped by the sanguine or pessimistic mood of the person scrutinising the figures. On the other hand, the usual practice is to endeavour to so arrange matters that any error may be, as is commonly said, "on the safe side."

Apart from the broad question whether any method of dealing with stocks and balance-sheets that allows latitude for error, even on the safe side, is quite good enough for the extensive and complex operations of modern industry, there is another consideration that should render any laxity on this score a thing to be certainly avoided.

The case of the "limited" or public company is here referred to, wherein shares are frequently changing hands, and the shareholder of to-day who has suffered by a "safe" error of method does not profit by the rectification of that error a year or half a year hence. He is, in fact, under such circumstances defrauded of his full return just as effectually as if an equivalent sum had been stolen out of the company's safe.

The question of stock values is as a rule beyond the purview of the professional auditor or accountant. He has neither time nor opportunity, nor indeed in most cases the necessary technical knowledge to detect any but the most palpable and glaring errors in the stock survey. He is therefore compelled to rely upon the figures

supplied to him by the technical arm, and of the vague methods employed to furnish the figures he has often no suspicion.

It is not the purpose of this article to lay down the lines upon which a satisfactory control or foreknowledge of the stock-taking values may be attained Such an aim usually requires a complete recasting of part or whole of the interior organisation, and is fit subject for a treatise rather than a short paper. It is proposed to deal herein with some of the more noticeable pitfalls surrounding the operation of taking out stock for the purposes of a periodical balance-sheet.

This operation may be discussed under three headings, viz. (1) Work under Manufacture, (2) Plant or "Value" Items, (3) Methods of Proceeding to take Stock.

WORK UNDER MANUFACTURE.

The valuation of work under manufacture in the ordinary run of engineering undertakings is commonly based upon "Costs," that is, on the generally subsidiary and unbalanced books of account known as "Cost Books." But as workmen's wages and cost of materials form but a part of the real cost of any article, there is usually an attempt to doctor up these figures of prime cost by the addition of a percentage for "Establishment Charges," viz., wages of foremen, cranemen, labourers, cost of maintaining and repairing machines, straps, shafts, cost of motive power, light and heat, and the thousand and one indirect expenses incident to manufacture, and which must be incurred and paid for out of pocket before one single nut, pin, or crank can be wrought into its final form out of the condition of raw material.

It is precisely here that the first and most serious pitfall occurs. The vaguest ideas obtain in many otherwise excellently managed establishments as to what constitutes a proper and just percentage to cover these charges. Unfortunately it is precisely here that the professional accountant is unable to render assistance. The question is not wholly, nor, indeed, greatly, one of figures, but one, in the first place, of technically adjusted method and in a very minor and arithmetical sense of accountancy.

To illustrate what is meant, a concrete case may be instanced. A very well known engineering works had, only three or four years since, the desire to put its internal affairs on a sound footing. To this end a firm of the first rank, whose name and repute are "familiar as household words," was called in, and amongst other things this very question of a correct percentage of establishment charges upon work under manufacture was propounded to them. The instructions given and acted upon were these:—"Take out the prime cost, viz., total of wages and material on all jobs in hand unfinished, and to this add so much per cent. for establishment charges all round." A delightfully simple rule!

The incident would not be worth mentioning (for there is no doubt that an equally absurd method is in vogue, almost universally, in engineering works in this country) but for the status of the firm endorsing it. That it is most dangerous and misleading will now be shown. It cannot be better shown than by tracing its practical working in the case of the works in question.

The business consisted of several varieties of work, but only two need be considered. One of these was a machine with a number of moving parts requiring careful manufacture and adjustment, the other was a heavy cast-iron or cast-steel article on which there was practically no workmanship. Observe now that the percentage for establishment charges was based on a prime cost. Hence at a stocktaking a large and heavy casting on which no machining worth mentioning had been done (and which therefore had not incurred any establishment charges) was actually surcharged higher than some of the smaller machines for the making of which the works chiefly existed. As a sidelight which may commend itself to those responsible for large undertakings, it may be pointed out that should it be desired to turn a bad into a good half-year in a place organised on such a system nothing is necessary beyond purchasing a large consignment of heavy

castings and putting them into the shops as jobs finished.

This brings us at once to the first fundamental precaution:—

ESTABLISHMENT CHARGES SHOULD NOT BE RECKONED ON MATERIAL BUT UPON WAGES ONLY.

In places where much handling of heavy material is a feature a nominal percentage, say four or five per cent., may be added to cover the cost of such handling. The possibility of "manipulation" of stock just hinted at is not the gravest objection to such a system. A much more serious matter is that no relationship exists between the total allowance for establishment charges surcharged to unfinished jobs and the real expenditure on such charges. But the most serious objection of all is that no relationship between the *work* and the establishment charges actually incurred *in that class of work* exists.

To illustrate this latter argument, let us assume that two classes of work are being manufactured on which the labour expenditure is, say, £50 in each case. Now there is all the difference in the world between establishment charges incident on men like instrument makers, brass-finishers and the like, who either work at a bench or use only ordinary or low-priced machines and the establishment charges incurred by planers, millers, grinders, or men using costly appliances requiring expensive maintenance, and taking up a large amount of floor space and consuming a great deal of power.

If, therefore, we surcharge an article worked entirely by the cheaper class of man and one which has passed through the machines of the other class at an *all-round rate* we are doing, to put it mildly, an extremely foolish thing. We are, in fact, to all intents and purposes, though innocently, falsifying the accounts.

That this is so will be clear when we consider that establishment charges represent indirect expenditure, out of pocket, incurred. They either represent this or nothing. And it will be equally clear that it is not enough for the manufacturer to know that the average proportion of establishment charges to wages is 50 per cent. to 100 per cent.; he also *must* know what articles are absorbing the bulk of this expenditure, because unless this is done it is quite possible in a moderately large shop that money is being made on one particular line and being lost on another line—the system of averaging establishment charges just serving to cover this fact up and leading to the supposition that all were equally profitable. It may be desirable here to consider more closely the actual items of establishment charges usually met with in engineering works.

The first large class comprises expenditure in the works, or, more particularly, in operations incidental to actual manufacture, and including the wages of foremen, gatekeepers, timekeepers, labourers, cranemen, yardmen, and others whose time, though not directly allocable to orders, is yet as much truly part of the cost of manufacture as that of a fitter or turner. In this class we must include another series of expenses, viz., those pertaining to the upkeep of the works in a state of efficiency, such being, cost of repairs to fixed plant and machinery, of sharpening and grinding tools, keeping shops clean, and whitewashing, painting, lime-washing, and so on. Yet another series will comprise an equivalent to a rent-charge upon the land and buildings devoted to manufacturing purposes, and interest upon the capital sums so sunk, together with the charge representing the actual decay or wearing away of the machines during the processes of manufacture called depreciation. All these expenses, though by no means allocable directly to any individual order, must yet be incurred before a single article can be manufactured. It is difficult to see, therefore, on what ground the case can be made out for omitting them from the costs, provided always that some attempt at an intelligent discrimination between the various classes of work absorbing particular classes of charges is made.

The other great division of establishment charges is that dealing with the

COSTS OF THE SELLING ORGANISATION.

Herein we include all office salaries, the costs of advertising, travellers, pattern making (where such does not distinctly

increase value) and the rent of the office buildings, and interest and depreciation on the furniture, fixtures, and appliances, such as typewriters, calculating machines, phonographs, telephones, and other costly labour-saving appliances now commonly employed in commercial offices. In this class, too, should be reckoned special depreciations due to obsolence of plant. Even in the absence of a method giving us the power of discriminating intelligently between work absorbing all classes of establishment charges and work absorbing only a limited proportion, it is still clear that the want of a definite relationship between the establishment charges incurred in any given period, say half a year, and the volume of work turned out in that half year involves a very serious danger.

It is clear that in no case should the proportion of establishment charges standing to the credit of work in progress in the stock sheets *exceed* the normal proportion obtaining, on the average, during the half-year, but, in the case cited above, where an all-round charge is put on to work in progress, there is no sort of guarantee that this average proportion may not be largely exceeded. Moreover, this official charge being fixed and not variable, it is practically certain to be at all times entirely out of harmony with the actual conditions of work in shops.

Thus, even where there is only one class of work passing through the shops, on which the establishment charges may be assumed to be equal on all orders in simple proportion to the wages incurred in their manufacture, the system is essentially bad, since it is a matter of pure luck whether the charges arbitrarily added happen to represent the real charges incurred, or are altogether fancy figures.

When it is remembered what a very important item the value of work in progress represents in most engineering balance-sheets this alone may well be considered to give plenty of food for reflection.

In some cases a more or less approximate idea of the *real* works charges may have been obtained, in which case an attempt no doubt has been made to provide a less crude method of valuation for stocktaking than in the case we have been considering. An all-round rate, which approximately represents the actual indirect expenditure, is a great advance upon the practice of using arbitrary rates, and may work with fair justice in cases where the variety of work is not great, but in the majority of engineering shops there is to-day some special class of article which the establishment, or rather part of it, has been specially laid out to produce, but which at the same time runs through the shops, side by side with other and, it may be, quite different work. In this case, a simple all round rate, however attractive from its delightful simplicity, is capable of working very serious injustice, when it appears as an element affecting profit in the balance-sheet.

To value things made in cheap buildings by cheap machinery and with a minimum of supervision at the same rate as specialised articles carried through by the aid of high-class machinery and a considerable indirect expenditure on foremen, inspection, gauging and so forth, means either one of two things. Either the cheaper class of work is being heavily over-valued, or the other class is being to a like extent under-valued.

The practical bearing of this is obvious. By the full amount of this under- or over-valuation, we are inflating or depleting profits, and, to this extent, assisting in the production of a false balance-sheet.

We may now sum up the pitfalls surrounding the question of valuing work in progress. No method allotting the due proportion of establishment charges can be satisfactory, (1) which bases charges upon prime cost instead of upon time or wages alone, (2) which makes use of an arbitrary charge, or system of charges, not based upon current, or at least upon recent, expenditure in the shops, (3) which, where there are varying classes of work being simultaneously manufactured, does not discriminate between them so as to surcharge those articles incurring heavy indirect expense with a larger proportion than those not incurring such expense. It will be seen that we have so far made no allusion to general establishment charges, viz., those pertaining to the selling organisation.

It is obvious, however, that it may be desirable in certain cases to surcharge certain classes of work more heavily than other classes on account of special expenditure incurred in the selling of them alone, but as reform must necessarily begin by correct ascertainment of the actual works charges it is hardly necessary to develop this stage of the subject in the present article.

It is difficult to make clear to the engineering mind the importance of correct establishment charges in connection with stocktaking, which is usually left a matter for the accountant to determine. Assuming that 25 per cent. of the capital sunk in an engineering works is represented by work in progress at any particular period, the importance of an error in the correct rate of establishment charge will be obvious.

An error of 20 per cent. in the valuation of work in progress is equivalent to five per cent. dividend on the entire capital, and few are the engineering works, indeed, which do not habitually run this risk in making up their stock sheets. In the old days, before specialisation had laid its grip upon the production of engineering details, all these questions of the correct appointment of establishment charges, depreciations, provision for obsolescence of machinery, could be slighted in the manner of the American manufacturer, who, when asked what system of cost-keeping he had in operation, pointed to a row of houses that he was building out of the profits of his business and said simply, "There are my cost accounts." To-day we may envy that man, we must not imitate his methods.

PLANT AND VALUE ITEMS.

The valuation of plant and similar items of fixed capital is less surrounded by uncertainty than work in progress. Yet as regards some items there may be in some businesses room for very serious error if suitable precautions are not taken. There are businesses in which loose tools play a very important part, and in which quite a large proportion of the capital sunk is locked up in small loose pieces of iron and steel, varying from a shilling to many pounds in value. Very rough-and-ready methods are often employed to ascertain the stocktaking value of the loose tools account. In the majority of cases no attempt whatever is made to make a survey of the articles themselves. This is frequently so, even where a fairly rigid inspection of the fixed plant, such as lathes with their attendant chucks, slides, centres, etc., is insisted on. Here again the "safe" method of dealing with values is much in favour, the cost of a new tool is sometimes written down by a third or even half its value before an entry in the official books of account. Once entered in that account the tool loses its individuality and is swallowed up by the works, all trace of its original cost being lost sight of. To remedy the confusion which such loose methods give rise to, a re-valuation of loose tools from an actual survey is sometimes made every five years or so. The more secure way of dealing with loose tools is to stamp every tool with a number so that its cost and date of manufacture may be at once known. Then, when taking stock, it is not a very difficult operation to have all the tools collected together and their numbers taken, from which at leisure and with the help of a little intelligent classification a much more approximate approach to the true value of the tools can be made. Here again, considering that in a works of moderate size a loose tool account may represent many thousands of pounds, the danger of rough-and-ready or "safe" methods will be realised without much difficulty.

The question of establishment charges upon plant and other addition to value is an important one. In the case of machinery requiring foundations and involving comparatively high costs of installation, it is a much disputed point whether the bare cost of the machine or the cost of the machine plus the costs of installation should be considered as the book value of that asset. It is not possible to enter at large into this question here. Attention may be drawn to a correct practice as regards the charging of establishment charges on such work as eventually finds its way to the official accounts. Herein again no arbitrary method of apportioning establishment charges is permissible. It is a safe rule

that no profit may be earned by the concern on things which it makes for its own use, in other words, they should be taken at cost. But this does not imply by any means that they should be entered at what is termed prime cost. The real cost of an article at the works gates is, as we have explained before, a very different thing from the mere wages and materials used up for its manufacture. The indirect expenses of the works are just as much a part of the cost as any screw or nut in the machine. Not so, however, the expenses of the selling organisation of the business. These two elements have no connection with each other, and we are not entitled to increase the cost of our plant by charging any of the general establishment expenditure upon it. It would seem, therefore, that a safe practice is to charge material, labour and works establishment charges on the latter, and consider this as the book-value of the machine or appliance in question. The depreciation of assets is of course a very serious and important item to be taken into account in balance-sheets, but as this item is a comparatively simple one it may be dismissed in a few words. The decision as to what is a correct rate of depreciation for any tool or machine is a matter for the technical expert to determine; but once this has been done, it remains only a very simple matter of pure accountancy.

The obvious precaution of varying the rates where a greater strain is thrown on to any class of assets by special conditions which have arisen since the last stocktaking, for instance, the working of machinery night and day, alterations in the uses of buildings, etc., conversion of a foundry into a forge or a smithy, or a stores into a warehouse and so forth, will be easily made.

The question of providing for obsolescence—*i.e.* the superseding of a machine before it is worn out, on account of the adoption of a superior type—is one which is, unluckily, often to the fore. This is certainly not a manufacturing expense, but an affair of policy. It must not therefore be allowed to influence costs in the shops. In certain cases it may be treated as a "general establishment" charge, or written down to profit and loss.

The very large items involved in fixed plant and loose tools render consequences of a false method in connection with a valuation of these items an obviously serious one.

METHODS OF TAKING STOCK.

At best, stocktaking is a nuisance. Like all other uninteresting occupations, it is shirked in consequence; yet, in the majority of cases, all bookkeeping and profit, and all the chances of a dividend, are entirely dependent on the accuracy of stocktaking.

Many of the items of the balance-sheet can be checked and their accuracy proved by the care and method of the accountant. Not so stocktaking values; over these he has usually no control. He does not know beforehand what they will be; he does not know afterwards whether they are correct.

Stocktaking is of course a practical operation which cannot be successfully undertaken by clerks, but must be in the hands of more or less practical men. The object of the most modern systems or organisations is to substitute the control of the accountant for the rule-of-thumb methods of the practical man. There are two ways, and two ways only, in which stock may be taken. There is the old way, in which the cost accounts, and the issues and receipts of stores are mere memoranda, subject to no check, and therefore as a general rule entirely at the mercy of the man who "can't be bothered" and the man who "forgets" to make an entry at the time he should make it, and from which consequently no positive results can ever be obtained save by the primitive method of going and counting up all the articles throughout the works on a given day and valuing them more or less accurately when counted. There is the new way, which requires of everyone dealing with the property of the firm in responsible positions—such as, for instance, the warehouseman and the storekeeper—that they should be able to give an account of what they have received and what they have done with such property.

When we have established as sharp control over the objects of value in the stores as over those other objects of value in the cash-box, we get altogether upon a higher plane, and are able to expect and to do several things which were before impossible. Where such a system is in operation, not only is the value of stores in hand and of work in progress known at the end of every month, but the stock that should be in hand of all principal articles, each individually, is also known. By this means we are enabled to substitute for the old plan of periodical stocktaking, with its consequent dislocation of all business, a system of "continuous survey."

A continuous survey practically means that some one official is regularly overhauling, taking stock, and comparing with the official accounts the items in custody of the storekeeper and warehouseman. The stock is, in fact, taken little by little every day. The results of this are very important; the storekeeper, not knowing what may next be called for, naturally becomes exceedingly careful in booking all movements of stores. When a man is liable to be called to account day by day for discrepancies which should not exist, and which only exist because of his own bungling, he naturally at first conceives a deep hatred of the new system; but eventually, if he is a wise man, accepts the inevitable, and the result to the firm is that it gets rid at once of a large source of inaccuracy in the cost accounts, and is enabled to obtain a close grip over its affairs which is absolutely unattainable where a method of this kind has not been adopted. The continuous-survey system leads also to a precision and order in the keeping of stores. A place for everything, and only one place for one thing, is a *sine quâ non* in connection with continuous surveys. A man of loose methods, whose vagaries cause endless troubles that are hidden from the knowledge of the management, is very quickly found out when a stringent method of control is introduced. The bearing of this system on the question of dishonesty is sufficiently obvious to need no comment.

Another excellent feature is that stock is not taken in such a case by those responsible for its custody as it is generally under the old method.

The question will suggest itself at once that the fluctuating value of certain articles, more particularly raw material, may cause trouble under this system. This is so, of course, but not more so than under the old method of stocktaking. It is true that at the end of the financial period it might be desirable to reduce the value of a large proportion of the stores, by reason of a fall in market values, but this becomes a matter of pure arithmetic, the quantity and individual prices of all the principal articles being already known. A word may be said as to the use of prepared inventories for stocktaking purposes. Where a continuous survey is in operation these are, of course, not required, but in stocktaking upon the old method it is a frequent practice to supply the works with written statements showing the chief items of value, to which the works are supposed to add the necessary figures. There is a certain amount of convenience in this method, but it is a very dangerous one, notwithstanding. Where a proper system of numbering all value assets, such as machines, appliances, loose tools, fixtures and so forth, is in vogue, it is infinitely safer to require from the works a simple list of numbers, the articles corresponding with which have been actually handled or seen by the person making the list. Under the other method duplicate entries are not infrequent, and it frequently happens that some perhaps important items which were not placed on the inventory by the office have escaped being scheduled altogether.

A. Hamilton Church

High-Speed Engines.

By J. H. DALES, A.M.Inst.C.E.

There has been a good deal of splitting of hairs at different times of late as to what a high-speed engine is, and so-called high-speed engines have been declared to be not high-speed at all, but "high-rotation," and so on, often in a way which was scarcely complimentary to ordinary mechanical intelligence — and there is little doubt that the majority of the makes on the market have little or no claim to the dignity of such a title, as there are but few whose combination of piston-speed and rate of rotation approaches what could be properly termed high-speed. Few, if indeed any, of the engines which are now used for dynamo-driving or similar purposes come anywhere near the combined piston-speed and rate of rotation which has been common in the ordinary locomotive for fifty years or more. Every day and everywhere on main lines express engines run between 1,000 and 1,200 ft. of piston-speed at rates of rotation of 250 revolutions per minute. Nothing like this combined rate is reached by any high-speed engine in every-day use, for the results obtained in torpedo-boat trials cannot be fairly termed every-day results. It should be borne in mind, however, that high-speed engines, on the average, have, in the matter of time, very different conditions to fulfil from those of the locomotive, the longest runs of which, at the speeds mentioned, not usually reaching two hours' duration, while dynamo and some other high-speed engines have to make continuous runs, at their highest rates, during whole days, whole weeks, and in some cases months without stopping; so that it is clear that no fair comparisons can be drawn between the work which was formerly required from engines running at high rates of rotation and that of the present time. "High-speed," as a technical expression, is evidently as good as any other in the meaning which it conveys, especially as it covers both rate of rotation and piston-speed combined, which "high-rotation" does not.

Special requirements first brought the present day high-speed engine into existence, and it has taken a good many years of labour and effort to put this class into its present position for general purposes, the pioneers, Brotherhood, Willans, and others having had a hard battle to fight in overcoming many deep-rooted prejudices and in demonstrating to the steam-using public that high-speed, or, perhaps, more properly, short-stroke engines, could be made to compete with long-stroke engines in the matter of steam economy and general reliability in working. Willans' tests in 1888, which are now a matter of history, placed these latter points beyond dispute, and it may be fairly said, established the high-speed engine. They demonstrated that cylinder losses decreased with increased rate of rotation in a remarkable manner, and clearly indicated the lines on which a compensation in fast engines might be obtained as a set-off against the inevitable clearance losses of the type.

In the results of these trials it became evident that the strokes of steam-engines and rates of rotation, as formerly designed for general purposes, had been too long and too slow for obtaining the most economical effects, even in the matter of steam economy, while in regard to first cost and maintenance they were also wrong. These may appear to be sweeping statements, but for proof of their general accuracy, a brief survey of the present position of the high-speed engine is all that is necessary. The survival of the fittest holds good perhaps more in mechanical matters than in any others, and if the class of engine under discussion is not better than what it has displaced, *in the most difficult work which a steam-*

engine has to perform, why does it exist? There are few, if any, functions, which a steam-engine has to perform, so far as its mechanical action is concerned, which are so difficult as electric lighting or electrical transmission of power; and, it may be asked, what electrical engineer who has had engines of the Willans or Bellis type for his work would go back to the long-stroke engine? And a further question may be put as to what body of directors (with no vested interests) would, after experience of the above makes, either pay for the long-stroke engines or the quadruple-sized buildings, foundations, and other accommodations which they require? Or for insurances against risks of expensive failures? Or for at least double the amount of attention day by day? Or for double the staff and appliances for handling? There is little doubt they would be difficult to find.

Very much has been learned by steam engineers in their struggles to overcome the inherent difficulties of high speed; the steam-engine as a work-producing machine, from a commercially economic point of view, has become better understood, and many obscure points in the physical action of steam in an engine have been cleared up, as well as correct principles of design of engines having been evolved. The forces generated by high speed, though, of course, of the same nature as those generated at low speed, are so exaggerated at very high rates that such as are scarcely apparent at low rates, and which may in such connections be practically neglected, have to be specially provided for, and it has been, so to speak, by testing to destruction that useful information and knowledge have been accumulated. Engine design has been practically revolutionised.

At the same time it would be useless to attempt to deny, if even there was any desire to do so, that the strong objections which were made to early examples of high-speed engines were in many cases well founded. Like many other innovations, early attempts were made in ordinary lines, and failures were the natural consequences; but in course of time engineers learnt what it was for which they had to provide, and of course they did it. A bearing to which no objection could be made at 100 revolutions was wrong for 200 revolutions, and that which was good enough for 300 revolutions was wrong for 600, and so on. It was a case of providing for the work, and having found the nature of the work the provision was no difficulty. The most enlightened investigators began with light shafts, and went heavier as the lighter failed, and so found the correct sizes, calculation in such cases being very difficult to apply with anything like exactness.

In like manner with lubrication. If a drop of oil on a journal takes one minute to work from the centre to the outside at 200 revolutions, it will be out in half-a-minute at 400 revolutions, and two drops of oil would be required in the time at the latter speed; or in place of this the journal would have to be twice as long as in the former case. In regard to other features the same kind of thing might be said. When, however, all the points had been found out and the remedies or provisions made to meet them, there was no more difficulty in running high-speed than low, in fact, the "points," by experience, became so much clearer in the exaggerated form of the high-speed results that they were better provided for than ordinary, and the engines much more reliable. In the sequence there is no ground for any supposition in the minds of non-technical people that they are paying for the very great advantages which are attached to the use of high-speed engines in a general way by running any sort of indefinable risks. Several advantages are entirely on the side of such engines, and their own particular points are not to be obtained from the larger type.

The advantages of high-speed are *very* general. They cost less than long engines, The best class of high-speed engine can be had of, say, 500 h.p., regular indicated, for £3 10*s.* per i.h.p., while long engines, class for class, would cost at least twice as much. They occupy less space; a compound high-speed engine of 500 h.p. would occupy 15 ft. by 6 ft. exclusive of pipe projections, while a 500 h.p. ordinary tandem compound, even when

arranged with the air pump underneath, would take up a space of 50 ft. by 12 ft. Relatively the floor spaces would be 90 ft. net and 600 ft. net, and the solid content of the necessary buildings for housing the two types would be about proportionate to the floor space, as the heights would be about the same, and as the cost of buildings is approximately as their solid content the long-engine house would cost six times as much as the short type, or, if foundations and general items be taken in, which is of course the only correct commercial view, the differences in the cost of buildings would be greater, power for power housed, than the relative floor spaces.

Perhaps a good illustration of what may be done in the way of space occupied is a late enquiry of a large electric lighting company for a three-crank triple-expansion engine and dynamos of 750 h.p., the available floor space being only 26 ft. by 14 ft. for the whole plant.

After the engine and engine-house, the next point to be taken in regard to cost is the attendance. The cleaning of a long engine is a large item, involving one way and another, in such a one as the example previously taken, an expense equal to the interest on a capital outlay of £1,000 in labour and material over and above the cost of the principal engineman or tenter; while in the case of the short engine of the vertical closed type, the cleaning item is almost *nil*, and in regard to general attention, there is very little to do even for one man. To be perfectly fair, of course the reason for two men being required in the long engine is partly that there is a large amount of dirty and unpleasant labour which the better class attendant will not do, but there it is, it has to be paid for; while in the other type, the necessity for the same class of labour does not exist. In reviewing these points, the oiling of shafting and other duties is not lost sight of. In the matter of lubrication, high-speed cylinders cost perhaps a little more than long-engine cylinders, though that is a matter of some doubt, while the "motion" of high-speed engines no doubt requires more oil than ordinary, but the item being a small one —under 6*d.* a day for 500 h.p.—is almost negligible. Oil at 1*s.* a gallon answers perfectly well for high-speed engines, covering the surfaces which are large, being the principal necessity. No expensive unguent is required, as the surface pressures are light, and certainty of action in the lubricating arrangements is of more importance than quantity; at the same time, quantity often insures certainty, and a large quantity of cheap oil is distinctly better—within reasonable limits—than a small quantity of more expensive oil. Then comes the reduced risks of running engine power. The high-speed engine is a much stronger machine relatively to the forces dealt with than the older type, and it is much less liable to breakdowns, its own little vices being of a much less important character than those of the latter. If a long-stroke engine runs away, for any accidental reason, extensive damage is almost certain to take place, not only to the engine, but to the buildings with which it is connected. The writer has a case in his mind where a new engine ran away. It had a 20-ft. flywheel, with many rope grooves. Why it ran away nobody ever knew, but it did, and burst its flywheel, the parts of which wrecked the section of the mill on which it was situated, cutting through 12-in. square beams in their flight, and some finally landing on the roof some 60 ft. or 70 ft. high, while others were "missing" and are supposed to be at the bottom of the reservoir. Damage to much more than the value of the engine was done, and the mill stopped for nearly three months. Many such instances could be cited, and are only such accidents as large engines are liable to at any time.

Such a thing could not happen to a high-speed engine or its flywheel, except in the very remotest contingency, and in no case could such extensive damage be done, as there is not the material to smash up nor sufficient relative force to do it. The engine in question was practically destroyed, and it was a marvel that nobody was killed. The accident happened also to rope-driving, which is usually supposed to be the safest. The governor evidently did not act, but why

nobody knew. Now, such an accident could not happen to a high-speed engine with shaft governor from any such cause. If the whole load was on one belt and that belt broke, a well designed high-speed engine would not run up 2 per cent. in any case, and if the governor happened to be well lubricated at the time, it would not run up more than 1 per cent. Here comes in a point in regard to the safety of shaft governors which, it may be said, can only be successfully applied to high-speed engines. Good governing can only be had, either for large or small engines, from a very high rate of rotation of the generating weights, and these necessary speeds have to be geared up from slow engines either by wheels or belts, both of which are in themselves an extra danger, as they may fail. The writer has known something like 300 incandescent lamps to be smashed in a few seconds from the failure of a governor belt, although the engine-man was not five yards off the stop-valve.

In regard to friction and engine-efficiency, the writer has often heard the remark from non-technical people, "but there must be a great deal of friction in engines running at this rate." This is quite a mistake; as a matter of fact the friction of a double-acting high-speed single-cylinder engine is between 4 and 5 per cent. of the full working load. That of the old beam engine was about this amount, and of most horizontal long-stroke engines it is more. The friction of a compound twin type double-acting high-speed engine is about 8 per cent. of the full load. Nothing any better than this can be made in long-stroke engines.

The comparatively small size of the high-speed engine makes it practicable to provide it with bearings and fastenings of a comparative large size and strength, which would be quite impracticable in a large engine, either from a technical, practical, or financial point of view, and, as a working machine, can in consequence of this be much more heavily loaded in a regular way than an engine built on the old lines, and that without running any risks whatever; in fact, so far as the maximum strains are concerned, stroke by stroke, the load on such an engine makes no difference to it, for the maximum strains are produced by the inertia of the piston line and always occur after the action of the steam in the stroke, usually coming at about three-quarters the piston travel. Of course, speed for speed, the maximum strains in this connection are always the same. This feature of strength gives a practical range of mobility to this class of engine which is not possessed by any other. The same engine can with profit be run at a speed, say, of 250 or 500 revolutions by simply changing the governor springs, thus doubling the working power and at the same time increasing the economy; the capital outlay at the lower speed, power for power, being, say, the same as ordinary, but which is reduced as the load is increased, and, of course, without any change of plant, except driving pulleys. This is a great advantage to a steam-power user; and especially in regard to compound engines, which must always be proportioned for fixed pressures and ratios.

Again, the small size of high-speed engines and their parts conduces very greatly to the practicability of duplicate manufacture, which both improves design by making careful consideration of every feature profitable, and cheapens production, which benefits both maker and user. At the same time this means, of course, standardising, which again is a guarantee to both maker and user of the attainment of certain results on certain lines, all tending to public benefit in the long run. It is a case of growing ten potatoes instead of eight from the same outlay.

This matter of duplication is of great importance to a steam-power user, as it saves him almost entirely from the risks of loss from stoppages of works. A case in the writer's experience gives a striking illustration of this. A horizontal engine of the high-speed type, doing about 120 h.p. on full load, broke its cylinder and one of its main bearings, in addition to other damages, at 4 p.m. on a Saturday afternoon. The "fireworks," the writer was informed, were lively while they lasted, but no one was hurt. The damage occurred from one of the crosshead bolts

(Marine pattern) giving way. The second was then wrenched off, and the small end of the connecting rod swung upward, knocked off a small steam-pipe, then fell in front of the slide, and the next revolution knocked off the back end of the cylinder, at the same time breaking one of the main bearing lugs across. No damage whatever was done to the shaft. The engine was one of a duplicated pattern. The manufacturing engineer was found on enquiry to be at the seaside, some eighty miles away, and from one difficulty and another, on account of the day being Saturday, it was nearly 9 o'clock before the new engine could be bought to replace the broken one. A further delay in getting the men together to load up the new engine and get out the old one was experienced also on account of the day of the week. The men's addresses were easily got at, but the men, or rather the bulk of them, were not to be found until "turning-out" time, so it was 11.30 p.m. before actual operations could be commenced. In spite of this, however, and a loss of five or six hours on the Sunday from a portion of the men getting away by mistake, the old engine was got out, the new one put in, coupled up, and set to work by 7 a.m. on Monday morning. If the accident had happened on any other week-day, the job could have been done in half the time, and no stoppage of work would have occurred. This is a point worth considering in buying an engine.

Coming to the matter of steam economy, a few facts of Willans trials may be useful in the consideration of the point. Without going into any indirect details, and the fact that the engine with which the trials were made was a very small one, by taking the "percentage efficiency" at different speeds, sufficient proof can be shown of the saving effect of increased rate of rotation; and as compound results are those of chief interest on account of the scale on which that principle is employed, and as also in which cylinder losses vary least, it may be as well to confine the inquiry to that type, in order to be most conclusive. Taking, for example, the results of a pressure of 130 lbs. steam and total expansion of 4·8 times at 130 revolutions, the percentage efficiency was 68·8, while at 405 revolutions it reached 80·0, thus showing a clear gain due to speed alone of a little over 11 per cent.

Now the next point to consider is, what the relative losses due to the clearances of long-stroke and short-stroke engines are. An ordinary long-stroke engine worked by a slide-valve in the centre, and with a port area of $\frac{1}{15}$ has a clearance due to the port alone of about 5 per cent. of the content of the cylinder, the cylinder end clearance, which must be assumed having to be added to this, and taking a 4-ft. stroke, which is ordinarily neither long nor short, and $\frac{1}{4}$ in. at the cylinder end, the added clearance would be $\frac{1}{192}$ or, say, $\frac{1}{2}$ per cent., a total of about $5\frac{1}{2}$ per cent. The 4-ft. stroke would run about 75 revolutions per min., while a 12-in. stroke high-speed engine would easily run 300 revolutions; but, in proportion to the example taken from Willans' trials, need only run 234 to be equal to those in percentage efficiency.

A 12-in. stroke high-speed double-acting engine with a side port and piston-valves can be made, and is made, with a total cylinder end and port clearance of 6 per cent., which, as will be seen, is very little over that of the long-stroke engine, so far as regards ordinary engine cylinders; but as it is the best class of each with which the discussion is concerned the Corliss valve is that which should be considered in comparison. The total cylinder end and port clearances, reckoned on the same basis as the 6 per cent before mentioned, would be $3\frac{1}{2}$ per cent. in an engine fitted with corliss valves and at four times the stroke (4 ft.) they would come to something less than 1 per cent., giving in the matter of clearance an advantage to the long stroke of, roughly, 5 per cent.

Now, average pressure losses due to clearances are for ordinary ratios of expansion equal to a percentage of about half the clearance ratios to the full capacity of the cylinders. Therefore, the high-speed engine would loose by reason of its 6 per cent. clearance about 3 per cent. of its theoretical efficiency, but by its increased rate of revolution would

gain 11 per cent., a profit of 8 per cent. against the lower rate.

The conclusions to be drawn from these trials are that cylinder losses are proportionate to time and not to the quantity of steam passed through them, for they show that after the transmutation of heat into power had been allowed for the missing heat per time unit was practically the same quantity at the lower as the higher rate of rotation.

The difference in the feed-water per i.h.p. was as 23·67 lbs. per hour at 130 revolutions, and 20·35 lbs. at 405 revolutions. This was with a boiler pressure of 130 lbs. and working compound as before mentioned. The difference in the feed-water was 14 per cent., and so by loosing 3 per cent. in clearances a high-speed engine would gain 11 per cent. by running the higher rate. This is the main commercial point as regards steam economy. To what extent this would take place in larger engines of the same type as the experimental engine, and how it would compare with long-stroke engines, is a matter for some speculation, and no doubt the differences would be less, but would doubtless balance the losses due to increased clearances and other natural consequences of the use of high rates of rotation. Practice proves this.

It is to be regretted that so few investigators have taken care to show distinctly what portion of the missing heat belongs to the conversion of heat into power.

It will be easily seen that the design of the most commercially economical engine requires very careful consideration to produce such a balance of rate of revolution and stroke as will give such desirable results, and that they lie within the range of high-speed practice.

The mechanical action of a high-speed engine is unquestionably very superior to that of low rates, both in so far as uniform torque is concerned and the possibilities of good governing, in which two points are embodied the whole duty of a steam engine or any other motive power, and the higher the rate of rotation the better such action becomes. At low rates the pulsation variation of single engines is commonly 5 to 6 per cent., and in extreme cases up to 12 per cent., while in one running 600 revolutions this falls below 2 per cent. Of course this feature makes a very great difference in the possibilities of close governing in the two types, apart from the speeds required for the governors proper. A wide range of pulsation variation makes it impossible to govern very closely, as such action causes racing in finely-adjusted governors.

In the matter of uniformity of torque the momentum developed by high rate of rotation plays a very important part, especially in connection with high grade of expansion of steam, the best results being obtained by a judicious adjustment of speed, weight of piston line, cut-off, and pressure. The best practical results and those most free from detrimental vibrations are those in which the tangential force line at the commencement of the stroke rises out of the crank path at a tangent. In such a case there is practically no shock at the reversal of the engine stroke, whatever the speed may be, and the successful attainment of very high rates (over 500 revolutions) depends upon this point. In very fast engines the chief difficulty of design in regard to this feature consists in making the piston line of sufficient strength out of the admissible weight, except in case of using an unusually high pressure. The inertia of the piston line in high rates brings about the heaviest strain on its fastenings and bearings, and this comes on, not at the beginning, but about three-quarters towards the end of the stroke, later or earlier as the speed is greater or less; and as pound for pound the weight of the piston line produces the strains upon itself, and limits the rate of rotation, the steam pressure must be such, and also the cut-off, as will balance this force without increasing it at the point of greatest strain. As will be seen in the design of such lines (piston), great care must be exercised to have no dead metal or any retransmitted strains, which multiply weight without adding to the direct strength. The strength and proportions of the shaft and weight of the flywheel are most important considerations at excessive rates of revolution. A shaft, which is amply strong for the piston

line, will carry only the lightest flywheel it is possible to make, in fact, carrying a flywheel of sufficient strength without vibration is really the main consideration. As regards the size of the bearings, the adjustment of the diameter, which is sufficient for the before-mentioned points without too much increasing its surface speed, requires both experience and care, and in regard to length every available inch which is not required for the crank cheeks should be put in, especially in regard to the crank neck, which, both in diameter as well as length, should be greater than the main bearings. The main bearings in a high-speed engine are no difficulty whatever, as they are stationary, and can be readily lubricated.

The chief difficulty of all, however, in connection with running of high rates of rotation is the knock of the bearings which are subjected to the reciprocating action of the piston. The faster an engine runs the greater the tendency the bearings and brasses have to get warm and expand, while at the same time, on account of the knock, as the speed increases, though more is required, the less clearance can be allowed, both on account of the hammer causing heat, and of the oil being driven out. Here is a paradox which presents apparently insuperable difficulties. To get over them Willans and others introduced single-acting engines, in which the thrust of the steam and resistance to the return stroke were all in one direction. Here, again, however, another difficulty soon presented itself in the momentum of the piston line, which, when it became, by reason of too great speed or too little steam pressure, more than the resistance, caused the bearings of the piston line to leave their journals, which resulted in a worse knock than in double-acting; and to prevent this, heavy compression, commencing at half-return stroke, had to be used. But even this was very difficult to maintain in stopping an engine, or in running on light load, and perhaps one of Willans' principal improvements in this class was the introduction of an air compression cylinder, in which the resistance could be adjusted, and which, when set, was practically constant. Of course the setting has to be made to suit the normal speed, and as its resistance must be equal to the inertia on the upstroke, the crank has to bear not only this on the downstroke, but the working steam pressure in addition, thus about doubling the load on the bottom bearing, by no means a good feature, but unavoidable in this class of engine.

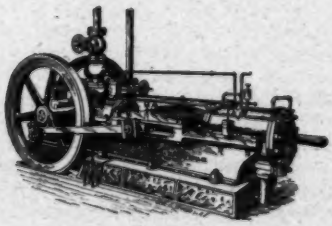
When a bearing of a high-speed engine runs hot the temperature will rapidly rise to that which is sufficient to burn off the oil or to melt white metal, and to be out of the range of the expansion caused by such heat in an engine of even small size —say with a 4-in. shaft—a clearance of $\frac{1}{60}$ of an inch is required; but this amount at 400 or even 300 revolutions would cause "steam-hammer" knock, and methods have been devised for double-acting engines to prevent this. Bellis and others have used copious lubrication, which to some extent cushions the bearings; others have made futile attempts with automatic adjustable bearings which were solid when close; others have had rubber or spring cushioned bolts, while lately a successful automatic adjustment, which is also expansible, has been introduced. All these will be dealt with later on.

The fact that the steam engine is, above all other considerations, a commercial worker, should never be lost sight of in its provisions: its sole object is to revolve its shaft at a certain fixed rate, with regularity and certainty, during all the time in which it is required to perform its functions, and that it is not in any degree a scientific instrument in the hands of its owners and users, but that the sole object and desideratum of its use is to obtain the largest possible amount of useful working force, for its first cost, driving and maintenance. How this maximum duty is obtained is of no interest whatever, on the average, to the user, the point being to get the maximum return for money laid out. Whether an engine does this by using the smallest amount of steam, or oil, or attendance, or by turning out the largest quantity of produce, is a matter of no moment whatever. One man wants cloth, another flour, another light, and so on, and so on, and he wants the maximum

quantity which can be obtained for a sovereign; and if in its internal processes an engine spends 6*d.* in one direction to save 1*s.* in another it is evidently doing the right thing, whether the limit of economy in every direction be obtained or not. Whatever combination will bring the largest issue of produce from the process is the correct one. This brings the very important matter of governing to the front. There is always a maximum rate at which any kind of produce can be made, and the closer to that rate the motive power can maintain the better the results will be. Of course, it is bad engineering to lose anything that can be saved to the general profit, but it is equally bad to save 6*d.* by losing a shilling, and when consideration is given to the fact that the cost of the coal bill is in a large mill not more than 2½ per cent. of the wage item, it is perfectly clear that bad governing may easily lose more than the value of the whole of the coal bill. Of course, in different trades the coal and other similar bills are more or less important or unimportant items according to their relative value to that of what has been termed the produce. In some electric lighting stations the coal bill is about 5 per cent. of the sale product, and this is probably as high as that item reaches in any business. Three tons of coal will run a locomotive 200 miles and earn £100. This comes to about 3 per cent. of the earnings. Of course these are approximate reckonings; so it would appear that in the case of electric lighting every 1 per cent. of the product would represent 20 per cent. of the coal bill. These are no fancy figures; close running to the limit is by far the most important point in steam-engine driving, and it is a point which can be most successfully obtained from high-speed engines. Their high inertia gives minimum pulsation, their rates of rotation give governing power from low inertia, which makes close adjustment possible. It is intended in subsequent articles to deal closely with the principles and practice of the various special and general features which govern the design of high-speed engines, both in regard to speed, strength, mechanical action, steam economy, governing, and management.

(To be continued.)

H. H. Dales



MACHINERY APPLIANCES AND PROCESSES.

"Every part and side of our life, from the cradle to the grave, has been touched and tended by the inventor and manufacturer. His works are as numberless as the sands of the sea, but the onward rush of Science and the Arts opens up new fields of discovery and enterprise as each day dawns. Let us choose here and there among thousands, and in choosing take the best as far as in us lies."

THE ELECTRIC-LIGHT PLANT AT MIDDLETON HALL, MIDLOTHIAN.

We illustrate overleaf the electric-light plant which has been fitted up by Messrs. Middleton & Townsend, of Edinburgh and London, for Mr. H. G. Moss, of Middleton Hall, Midlothian. In Fig. 1 the plant is shown as it was fitted up for trial after construction and erection at the works of Messrs. R. G. Morton, of Errol, Perthshire. It will be seen from the figure to consist of Morton's high-speed enclosed-type engine, which is supplied with steam from a locomotive type boiler built by the same firm. This boiler is provided with a specially large fire-box, in order that it may burn cheap fuel, such as wood or dross. The boiler is fitted with a full set of mountings, asbestos packed, and a close inspection of the photograph will show that these fittings are on stools projecting beyond the logging. There is a double spring-loaded safety-valve fitted on the top of the boiler, as shown in both figures, and two water-gauge glasses are fitted in the front. The feed-water is supplied by a 4-in. Weir feed-pump, capable of providing 400 gals. of feed-water per minute. The steam pressure is 120 lbs., and the steam is taken from the forward end of the boiler to the vertical separator standing on the left end of the frame of the engine and dynamo (Fig. 2.).

The engine is of a very special construction, and its work has given great satisfaction. As has been mentioned, it is of the high-speed enclosed type, coupled direct to the general electric dynamo. Its cylinder is 6 ins. diameter and 6 ins. stroke, and when making 550 revolutions under 120 lbs. steam pressure, it develops 25 b.h.p. The piston is light and strong, and of the conical pattern, and is fitted with two cast-iron Ramsbottom rings. The steam is distributed to the cylinder by means of a trick valve, giving a small travel and large opening for steam. In the larger sizes of engines, additional care has been taken to lighten the friction on the valve faces, for the valves are balanced. There is a distance-piece fitted on the top of the casing to carry the cylinder. This distance-piece is fitted with stuffing-boxes and glands top and bottom, the top one serving as the stuffing-box for the cylinder, and the lower one to prevent the oil from rising up from the inside of the casing with the piston. Stuffing-boxes and glands are fitted to perform the same functions for the valve rod.

The forgings of the engine are of Siemens-Martin steel and the bearings of gun-metal, the latter of ample dimensions, to prevent overheating. As is usual with high-speed engines required to run long periods without stopping, the oil is supplied to all the working parts through a system of oil channels under pressure by means of a valveless oil-pump. The plunger of this pump receives its motion from the slide-valve eccentric, and to clean the oil before it is pumped into the oil channels it is drawn through a strainer. In order that the oil pressure should be nicely regulated, a small hand-wheel is provided.

The engine is regulated by a governor of the Pickering type, driven in this particular case by two three-eighth inch cotton ropes, which receive their motion direct from a pulley on the shaft; these ropes are clearly shown to the left of the engine (Fig. 2). In some cases the governor is driven by a Renolds silent chain, but in the larger sizes of engines the governor receives its motion direct from the crank-shaft, and a speed adjuster is also fitted. The governor has power to regulate the engine so that it does not vary 2½ per cent. in speed in

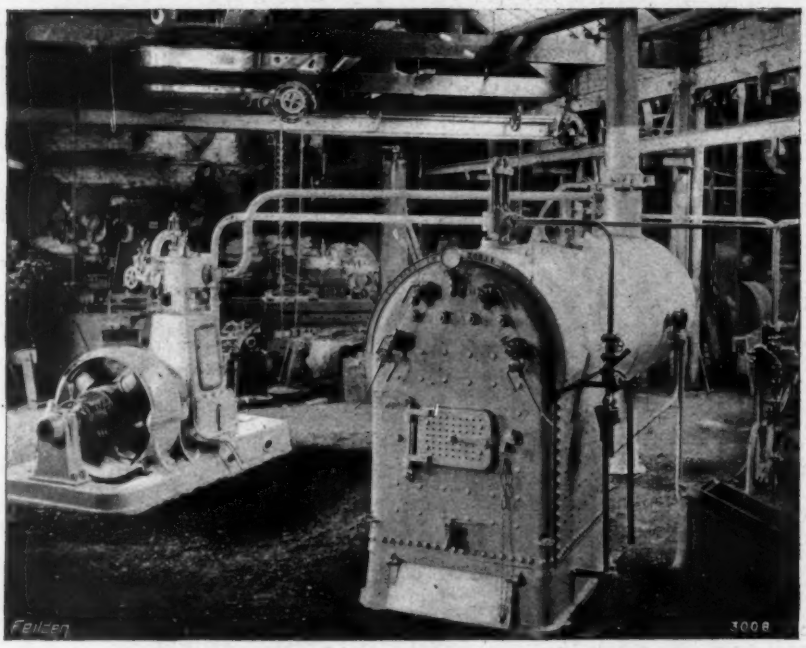


FIG. 1.—THE ELECTRIC-LIGHT PLANT AT MIDDLETON HALL. THE PLANT AS IT WAS FITTED UP FOR TRIAL.

changing from no load to full load, and sometimes, by a careful manipulation of the speed adjuster, the variation has been reduced to 2 per cent.

In order to provide ready facility for examination of the engine inside the casing two doors have been provided, the front one shown in Fig. 2 being provided with hinges.

Before the steam passes into the cylinder it is drained of any water by passing through the separator, shown on the left of the base (Fig. 2). As the speed is high it is necessary to guard against vibration, and the fly-wheel is thoroughly balanced and turned all over after it has been fitted on the crank-shaft. The dynamo coupling will also be seen to be fitted to the boss of the fly-wheel.

There is a recess cast in the extended bed of the engine for the waste oil and water. This waste oil and condensed steam is drained into the recess by drain-pipes, and after it has settled and the water been drawn off the oil remaining is strained, and afterwards pumped through to the working parts of the engine again. The crank-shaft is fitted with balance weights to ensure thorough balancing and freedom from vibration; and it runs quite smoothly and noiselessly even when running at 600 revolutions per minute.

A 200-H.P. LIQUID FUEL BURNER.

CLARKSON SYSTEM.

THE figures on page 580 are sectional and detailed views of a very large oil burner of the Bunsen type, recently constructed by the Clarkson and Capel Steam Car Syndicate, of Deverell Street, Great Dover Street, London, S.E., for supplying the heat necessary to raise steam in a 200-h.p. water-tube boiler in one of the fire floats on the River Thames in substitution for coal-firing hitherto used. This burner is so constructed that a start may be made at the shortest notice, and for this reason a small flame is kept

constantly burning day and night, and the boiler has always a little steam, which is increased within a minimum of time to the amount required for propelling the vessel with full steam the moment the officers have come on board.

The oil supply is contained in two long rectangular tanks of about 400 gals. capacity, placed at each side of the engine-room, and the quantity required is pumped into a copper reservoir to a pressure of 40 lbs. per sq. in. against a cushion of air, gauges being provided to indicate both the pressure and the quantity of oil contained within the reservoir.

From the reservoir the oil passes through the pipe shown by the dotted line in our illustration to the vaporising coil, through which it circulates, and the vapour thus produced arrives at the inlet valve chamber situated near the right-hand end of the nozzle, whence it escapes for mixture with the air by an aperture controlled by a needle valve.

The burner is furnished with a V-shaped valve attached to a stem, which can be moved vertically by means of a gearing device operated by the hand-wheel seen in our illustration.

The quantity of oil pumped into the reservoir is automatically adjusted in accordance with the rate of consumption, and, therefore, once the burner is ignited, it will go on working so long as any oil remains in the tank, whether the rate of consumption be high, low, or medium, without any adjustments of the oil pump being required. At its maximum power the burner is capable of producing considerably over 100,000 British thermal units per minute.

A special feature of the Clarkson system is that the burner may be turned down, and burns perfectly, however low the flame may be, so that while the vessel remains at rest only a very small fraction of the maximum supply is consumed.

The igniting of the burner in the first instance is effected by compressed gas, which is burned in a series of jets around the

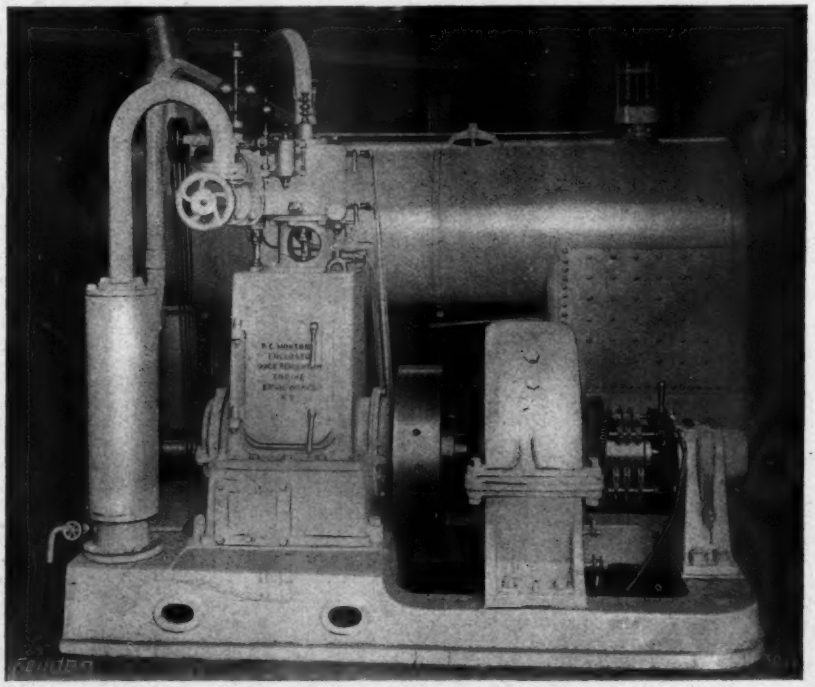
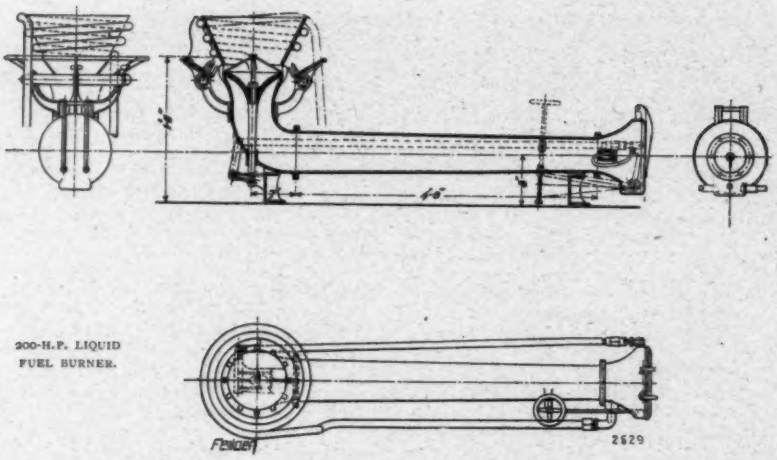


FIG. 2.—THE ELECTRIC-LIGHT PLANT AT MIDDLETON HALL.



200-H.P. LIQUID FUEL BURNER.

vaporiser, the gas cylinders being fitted with gauges and reducing valves to maintain a proper working pressure.

Many burners constructed on the same principle have been built by the firm above named, and are working in various parts of the world on motor carriages and wagons, steam yachts, launches, fire-engines and other purposes; the burner here described, however, is the largest Clarkson burner ever built, and in fact there is little doubt that it is the largest burner embodying the Bunsen principle in existence.

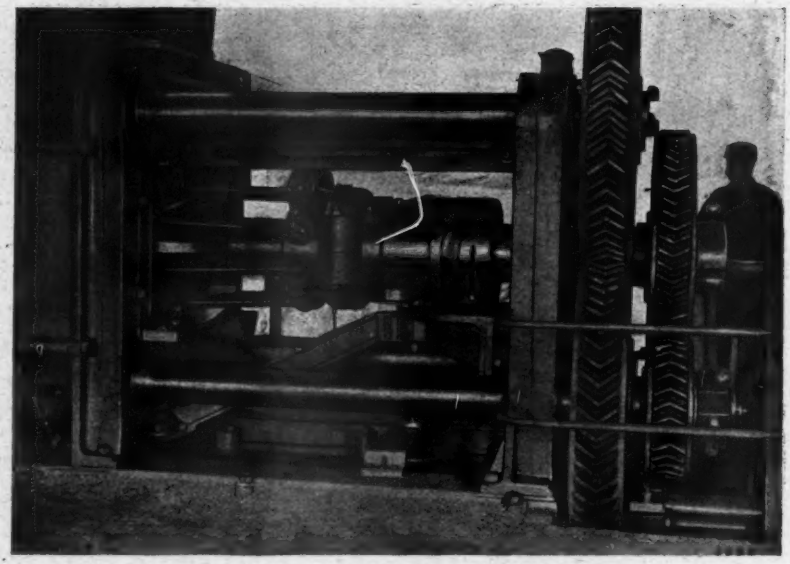
THE STRATHERN WELDLESS CHAIN.

SINCE Robert Flinn began in 1808 to make chains by welding hoops of iron together, the chain-making industry has grown to very large dimensions in this and other countries. The industry is still a handicraft, for each link requires to be welded separately by hand.

Engineers have had in view for some time past the possibility of making chains by machinery from a rod, but up to the present the success has not been marked. Until recently no chain-making factory has been established to make chains without a weak welded joint. A few years ago the Patent Weldless Steel Chain and Cable Co., Ltd., took up the manufacture of chain by Rongier's process at Gartsherrie, N.B. Rongier used a steel bar, the section of which was in the form of a cross. All operations were performed cold. Holes were punched in the webs until rectangular shaped rings were left. Then these were rounded off by pressing between dies. The amount of material punched away was about equal in weight to the remaining chain. The size was limited to about $\frac{3}{4}$-in. chain, owing to the bars having to be punched cold. Although many tons of excellent chains were made by the Rongier process, it was found that the manufacture could not be continued profitably on account of the low limit in size and the excessive waste of material.

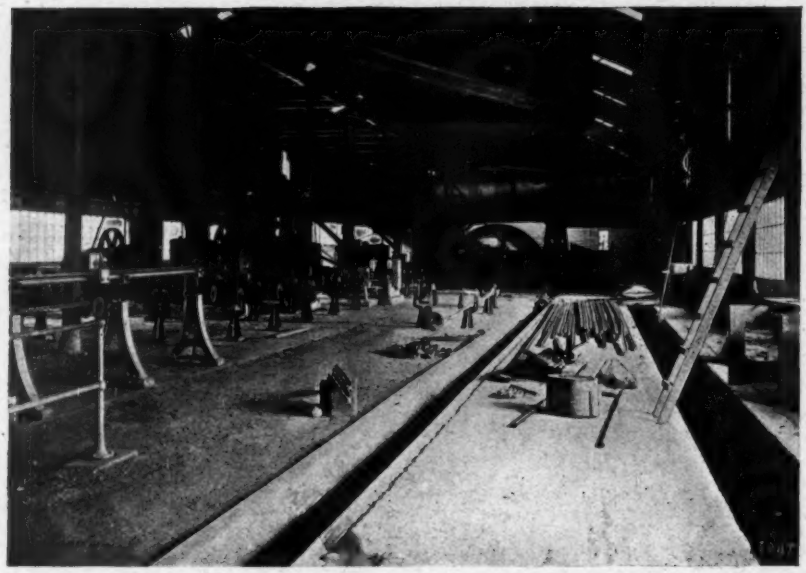
Before the Patent Weldless Steel Chain and Cable Co. discontinued the manufacture of chains by Rongier's process, they had the good fortune to appoint Mr. Alex. G. Strathern, A.M.I.Mech.E., as their works manager. Mr. Strathern soon perceived that if weldless steel chains had come to stay, some cheaper and more satisfactory method of manufacture must be adopted, and in order to make the larger sizes the chief process must be performed while the material was in the hot state. He then set to work to design a machine which would automatically press or forge a long red-hot steel bar of cruciform section into the form of chain links. After long and tedious effort he at last got the machine completed and set to work. The machine has every prospect of revolutionising the chain-making industry, and changing it from a simple handcraft to a plain manufacturing process

The problem which Mr. Strathern had to solve was to produce a machine which would be capable of exerting the necessary pressure on the link-forming dies to forge the chain



THE STRATHERN PATENT WELDLESS CHAIN-MAKING MACHINE.

THE STRATHERN PATENT WELDLESS CHAIN: PILE OF FINISHED WELDLESS CHAIN. THE CHAIN IS ALSO SHOWN TRAVELLING TO THE WEB-REMOVING MACHINE.



THE STRATHERN PATENT WELDLESS CHAIN: INTERIOR OF CHAIN-MAKING SHOP, SHOWING TESTING AND EXAMINING PITS.

links throughout the length of the bars and with the maximum economy in material. This means that the greatest possible amount of material in the bar must be pressed into links and the scrap reduced to a thin film. The machine had also to be capable of automatically withdrawing the bar from the furnace and at such a rate of speed that a very long bar would receive the required amount of heat during its passage through the furnace and so obviate the necessity of constructing a furnace equal in length to the bar to be heated. At the same time the machine had to work continuously so that the bar would not be allowed to rest in the furnace and become overheated, and proper provision had to be made for the regular cooling of the dies. It will be seen how excellently the machine was made to answer all the purposes for which it was intended.

Patents for the machine and process were taken out in 1897-98 and 1899. These, together with the works at Gartsherrie, have been purchased by Strathern's Weldless Chains, Ltd., and we give an illustration of the machine as now erected at the company's works. It will be seen to be of a massive description, and has been designed to turn out steel chains up to 1 in. diameter.

The machine is built close to the furnace which heats the bars, and is seen in the left of the figure.

The bar is fed into the machine through the furnace, and comes through the central hollow shaft with the links stamped on it. The machine, it will be observed, consists of a frame carrying a main central shaft and four others, in which the four massive gear-wheels are fixed. The main framing and gearing are of cast steel, secured to a heavy bed-plate in the usual manner, but with special arrangements for easy access for overhauling. The driving gear consists of the first motion shaft, on which is mounted a heavy fly-wheel and grooved pulley driven by rope-gearing, to which is attached one of Cowlishaw, Walker & Co.'s elastic clutches, together with the pinion for actuating the intermediate shaft.

The intermediate shaft is geared direct to four double helical toothed wheels fixed on to four steel crank-shafts. These shafts actuate slides which give the outward and inward movement to the stamping dies.

They have two motions, one rotational

and the other rectilinear. The rotational motion they obtain from a cam which is carried by the hollow central shaft. As the cam rotates with the shaft it is pulled by a fixed pin to right or left, and so gives the cam its rotational motion. The rectilineal motion of the cam is obtained from the cranks at the ends of the four shafts referred to above. The action of the machine in stamping the shape of the links of a chain on the bar of cruciform cross-section is as follows :—

The plain steel bar of modified cruciform cross-section is placed in the furnace, which is 30 ft. long, and, under the flames of the Dowson gas supplied, it is soon brought to a red heat. It is then pushed forward sufficiently to allow the dies of the pressing machine to engage it. These dies are in duplicate sets, and are arranged radially around a common centre in such a manner that they press simultaneously on the four angles of the bar. As the machine proceeds, the dies are, at a given period of its rotation, pressed inwards, and as near as possible touch each other, and, being curved longitudinally, they describe an arc of a circle as the bar moves forward, this arc being about equal to the length of the dies. As soon as they have stamped the shape of the chain on the rod, they are withdrawn by the cranks providing the rectilineal motion, and then the heated dies rotated backwards. In this position water is run on to thoroughly cool them before they are again brought into use.

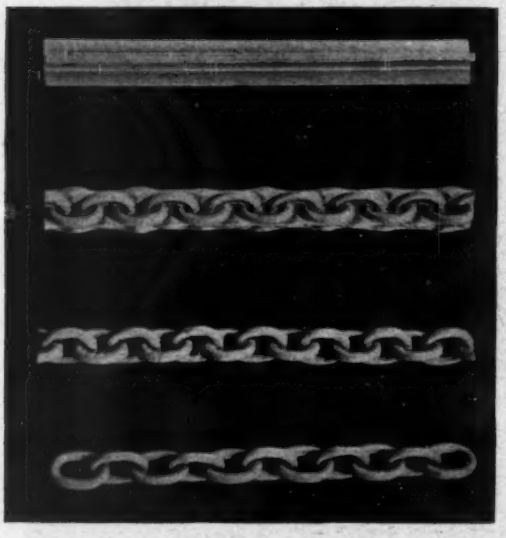
As the one set of dies rotates outwards to be cooled, the other set moves inwards to stamp other links on the bar, and these second sets are so arranged that they engage with the bar at the exact spot where the preceding set left off. By means of the cam-gear these are made also to describe an arc while pressing the bar, and when they have done this they are withdrawn to be cooled in the same way as described in the case of the first set. In this way the one set of dies is always withdrawn out of action for cooling while the other set is compressing the bar and forming links upon it.

The feeding forward of the bar is accomplished by the rotational motion of the pressing dies, and thus from the moment the pressing dies catch hold of the bar it is fed forward at a rate depending on the rate at which the machine is driven ; and the action is entirely automatic. The rate of progress of the bar through the machine while having $\frac{7}{16}$-in. chain stamped on it is 8 ft. per minute. The length of bar which the machine and furnace can deal with is limited only by the length of bar which the rolling mills can produce. A furnace of 30 ft. length can heat

VIEW OF THE STRATHERN PATENT WELDLESS CHAIN CO.'S WORKS.

a bar as it travels through at the rate of 8 ft. per minute, hot enough to be dealt with by the machine; that is to say, that a piece of bar going in cold at the end of the furnace and travelling through it at the rate mentioned, has become hot enough at the other end of the furnace to be operated upon by the machine. While the chain-bar goes through the machine it undergoes a process of stretching. While the present writer saw the chain being made 37 ft. bars were used, and the chain-bar which came from the machine was 47 ft. in length.

This chain-bar is seen at 2, in the illustration below, the original bar from which it is made being shown at 1. If this chain-bar



THE STRATHERN PATENT WELDLESS CHAIN: THE PROGRESSIVE STAGES OF MANUFACTURE.

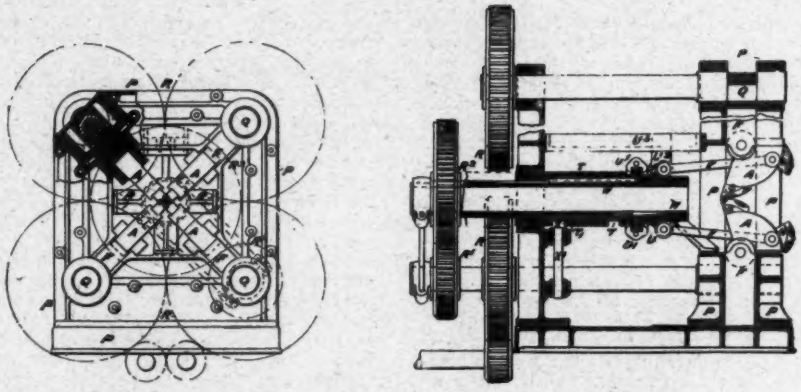
be examined through a powerful glass, it will be seen to consist of links lying alternately at right angles to each other. In the middle of each link there is a thin web about $\frac{1}{32}$ in. or so thick, and round the outside edges of the links there are similar thin films or webs left. The remainder of the process has to deal with the removal of these webs inside and outside the links.

Before going on to describe the further parts of the process of chain making on this system, it may be as well to explain clearly the construction of the remarkable machine as erected in the works at Gartsherrie. The object to be effected by the machine has already been laid down. That object is to stamp on the bar of cross-shaped section the links, and leave only a thin web remaining inside and outside their form. While the dies are stamping the forms of the links on the bar, it must feed it forward an exact distance. It is further necessary that each pair of dies be withdrawn and are undergoing cooling while the other pair is stamping and feeding forward the bar. It will be seen how this has been accomplished by the Strathern machine.

The sectional elevation of the machine and the end elevation are shown in the figures on page 585. First of all it will be seen that the mechanism of the machine is carried on strong frames, *P P*. At the corners of these frames are centred short shafts *Q Q* seen in both figures. Each of these shafts carries an eccentric pin which actuates the sliding blocks *F*, carried in guides; these blocks extending towards the centre of the frame. These blocks *F* again are provided with arms of the shape of a sector *A A*, pivoted in their inner ends, and they carry wedge-shaped dies *S S*, suited to enter the angles of the cross-shaped bar when the sliding blocks *F F* are advanced by the action of the eccentrics which are fitted on the shaft *Q*.

The oscillating sectors *A* carry two or more dies *S*, which permit of the dies being brought into action alternately or successively. The crank shafts *Q* are geared together and obtain their motion from the large spur wheels *R R*, and so the dies are brought to act on the bar simultaneously and with exact precision. It will be seen that the acting faces of the dies *S* are curved, the curves being described from a centre considerably to one side of the pivot. The advancement of the sliding blocks *F* carrying the dies *S* causes them to rotate and crush the bar into link forms.

The rotation of the dies is next to be considered. It will be seen that the sections *A* have attached to them strong drag links *V V*, and these are attached at their other ends to a non-rotating sliding sleeve *U* and a rotating cam. This cam *T* consists of a sleeve which surrounds a hollow shaft *W*, and has a scroll *T*, shown also in the figure, cut in it. There are portions of this scroll



THE STRATHERN WELDLESS CHAIN: END AND SECTIONAL ELEVATIONS OF THE CHAIN-MAKING MACHINE.

at right angles to the axis of the sleeve, while other portions are inclined as shown. By means of the pin fitted into this and fixed outside of it the necessary sliding motion is given to the cam sleeve *T*.

This sliding motion is produced as follows: —The cam sleeve *T* slides on the hollow shaft *W*, and it is rotated by means of the feather key shown. This shaft *W* is driven by the spur wheel secured to its outer end, and which gears with a pinion on one of the crank shafts, and the gearing is such that the hollow shaft *W* revolves at half the speed of the crank shafts *Q*.

The cam sleeve *T* is connected to the sliding sleeve *U* by a loose ring U^1, made in halves. This allows the cam sleeve *T* to rotate while the sleeve *U* is prevented from rotating by an extension U_2, which engages a stationary part U_3 of the framing.

The scroll *T*, on the cam *T*, fulfils the following purpose: — There is a small roller *X* which runs on the stationary pin *X*, and causes the sliding action of the scroll cam *T* and the sleeve *U*, and consequently a rotating movement of the dies *S*. After the dies have moved along the bar the necessary distance a straight part of the scroll comes to the roller *X*, until the dies are withdrawn from the bar. Then another inclined part of the scroll *T* comes into action and pulls the cam sleeve *T* and sleeve *U* along, and rotates the die arms *A* the distance required to bring the second set of dies *S* into position. The second half of the scroll is of the same shape, and the same forward and withdrawing motion is given to the second set of dies *S*, and when these have been withdrawn the scroll takes back the sleeves *U* and *T* to the original position. And the same kind of operations are gone through again and again as long as the machine continues to move.

After the chain-bar has passed through the pressing machine it has the appearance represented in 2 of the illustration on page 584. The next step is to remove the thin film or web surrounding the links. This is accomplished by feeding the bar through a special punching machine, actuating punches which remove the film surrounding the outside and inside of one link at each stroke. The punches descend first on the horizontal web of the bar and remove the film as indicated; the bar is then rotated through a quarter of a circle so as to bring the web which was vertical into the horizontal position. The bar is then fed forward in accordance with the pitch of the links, and the punches again descend and remove the film as before. The bar is again rotated and fed forward, the same operations being repeated throughout its entire length.

When this has been done the chain is in the condition shown in 3 in the illustration (page 584) There still remains a small attachment of metal between the insides of each pair of adjacent links. This small section of metal has next to be removed. This is done by passing the chain through a special machine which twists or rocks the links relatively to each other as one would break a rod by bending it backwards and forwards at a particular place until it breaks. This bending action soon breaks the little piece of metal between the links, and then the links are all separate pieces of solid metal. After this the links

are pressed cold between dies, which gives them a smooth finished surface. Finally, the whole chain made from the original solid bar is put in a rumbling barrel with a number of scraps of steel inside, and it is there shaken until the whole surface is polished bright. It is then taken from the barrel and annealed.

The chains are then taken to the testing machines. It is here tested in a hydraulic testing machine, similar to that used in Lloyd's proving houses. Tests were witnessed by the present writer of a $\frac{7}{16}$-in. chain, and the result showed that the weldless chain could stand a strain of 9 tons before it broke, while the Admiralty breaking load of such a welded chain is $4\frac{1}{2}$ tons. Indeed, in every test which has yet been made, the breaking strain of Strathern's weldless chain is about double that of the welded chain as tested to the Admiralty breaking strain for that size.

This greater strength of the weldless chain may be accounted for in several ways. First of all, the material being steel, and the absence of welds, render it much stronger than the common welded chain; secondly, the link can be made of any shape by means of dies, while the welded chain can only be made with links of the same section throughout. This possibility of making the link of any required shape involves a great principle, which allows the weldless chain to be made of much greater strength than the welded one. The weak point of a chain is the part of the link bearing on its neighbour. When the chain is pulled that part of the link is subjected to bending, while the sides are under tension. Bending is much more severe in the link at that part. Hence, to make the link of one strength throughout, the ends should be made of larger section. In this weldless chain the dies are formed so as to give the ends of the links a larger section. Then, again, the welds in a hand-made chain reduce the strength greatly. Tests have shown that the strength is reduced from 10 to 40 per cent. by the weld. An average would give about 20 per cent. reduction of strength. By this process, then, the links are made much thicker at the ends than at the sides in accordance with the principles referred to above. And this arrangement not only carries out that principle but ensures much longer life to the chain, as it can be much longer in use before its dimensions are reduced at the ends even to that of an ordinary chain.

Then, again, when chains of equal strength are required, the weldless chain is practically about half the weight—strength for strength. On the other hand, if the same size be employed, the strength of the weldless chain is about double that of a common chain, and consequently has a much higher factor of safety if used to lift the same load.

For the manufacture of the weldless chain large works have been erected at Gartsherrie, N.B., and fitted with the necessary machines, furnaces, and tools. The general view of the works is shown on page 583. The plant at present consists of Dowson gas producers of the largest size, working in conjunction with a gas furnace of the "Weardale" type; this being for heating the bars before it goes into the machine as described in the process. There is also the chain-pressing machine capable of pressing links ranging from $\frac{1}{4}$ in. to 1 in. diameter of cross section. There are numerous special punching, trimming, separating, and finishing machines. The powerful hydraulic testing machine has been referred to, and the testing and examining pits are shown on page 582.

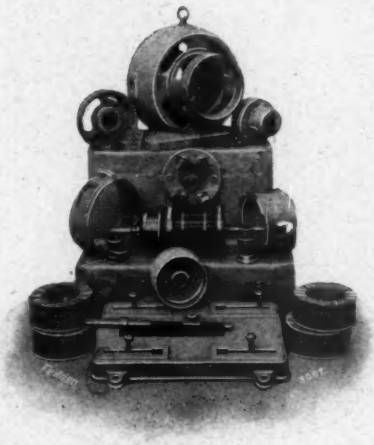
The writer understands that the Company are about to make important additions in the existing plant, and designs are being prepared for machines to make larger sizes of weldless chain. When these additions are completed, the works will be capable of producing a large weekly output. G. H.

The Editor of "Feilden's Magazine"

Cordially invites his readers to send him early particulars of New Machinery, Improvements, Novelties, etc., for inclusion under this section. No charge whatever is made for the publicity afforded or for illustrations, nor is any *quid pro quo* expected. FEILDEN'S MAGAZINE undertakes the whole of the cost, merely stipulating that proper details, photos, blue prints or tracings are supplied. If necessary, we will send our editorial representative to inspect and report on any special subject. The Editor, however, reserves to himself the right of accepting or rejecting any matter.

HOW GREAT BRITAIN IS MEETING FOREIGN COMPETITION.

2.—Specialisation.



THE first of the series of articles on this subject, which appeared some three months ago, had for its object the illustration of the manner in which a certain organisation had laid itself out to meet competition from abroad in a specific industry, an industry the growth of which had been checked perhaps more than any other by the advanced methods of production adopted by Continental and American manufacturers.

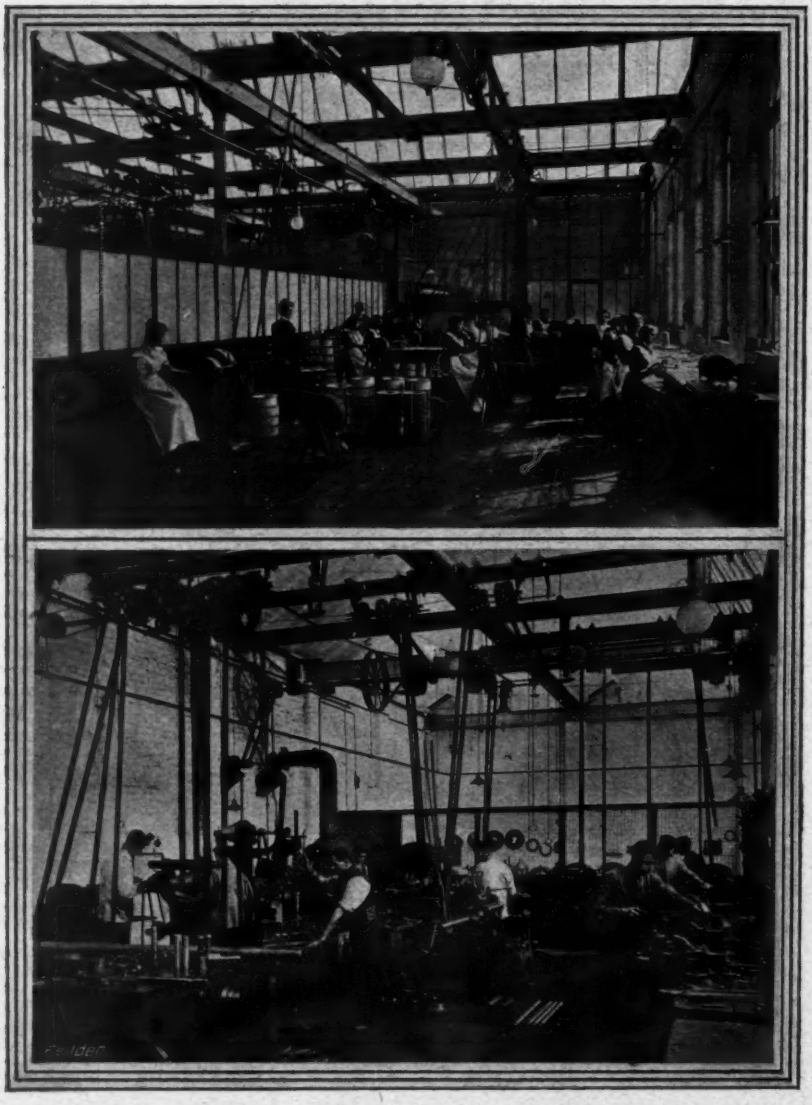
It is proposed, however, in the present article, to deal with that aspect of production denoted by the term specialisation, and to illustrate the principle governing the application of a method so universally and successfully adopted in America by a description of the works of two of the most up-to-date, if not the largest, shops met with by the writer in the course of his visit to the various manufacturing centres of this country. It will be advisable at the outset to see what the term specialisation really means and under what conditions the adoption of repetition methods become possible or profitable.

Specialisation, which has for its prime object the reduction of the time and cost of production, is that method of manufacture by which the output is restricted to one or more given *types* of product, the component parts of which are made by machines specially adapted for turning out such parts ; instead of, as is the prevailing practice, of using one machine for a large variety of purposes, and furthermore to restrict the manipulation of such machines to one workman in order that he may thereby attain a high standard of efficiency. This definition has no pretension to adequacy, but simply states the fundamental principle of specialisation. Its fullest meaning will become apparent as the various considerations affecting it are discussed.

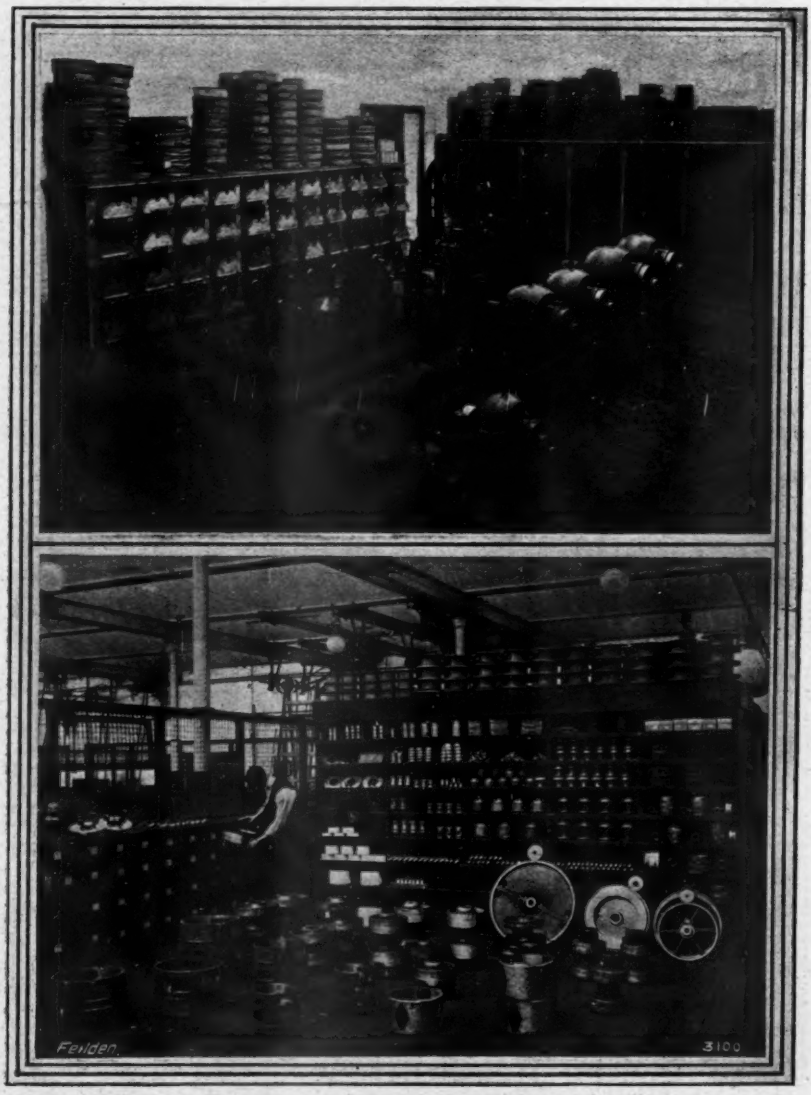
It must be assumed at the outset that the commercial conditions are such as to permit the adoption of the system ; that not only a sufficient market exists, but that there is sufficient justification to assume that in the scientific principles which regulate the lines of construction of the product some definite stage has been reached to warrant the installation of a special plant without fear of any immediate likelihood of new discoveries rendering it comparatively useless.

Twenty years ago it would have been impolitic to have advocated specialisation, particularly in the electrical industry, which was then in a nascent state, but rapid development on well-defined lines has brought us to a stage at which, with some justification, special plant for special purposes could be adopted without fear of such a highly specialised equipment being rendered obsolete before its utility has been impaired by ordinary wear and tear or by some sudden and unexpected discovery.

There are numerous examples to-day outside such fundamental parts as bolts, screws, gear-wheels, shafting, pulleys, etc., the production of which has been brought to a high degree of specialisation even in this country, as, for instance, stationary steam engines. dynamos, motors, locomotives, gas and oil engines, looms, without mentioning others, in which the fundamental differences are sufficiently small as to call for the employment of special equipment for their profitable production. For example, a close examination of the various types of electrical generators, as represented by the exhibits at the Glasgow Exhibition, led to the conclusion that recent developments were of so minute

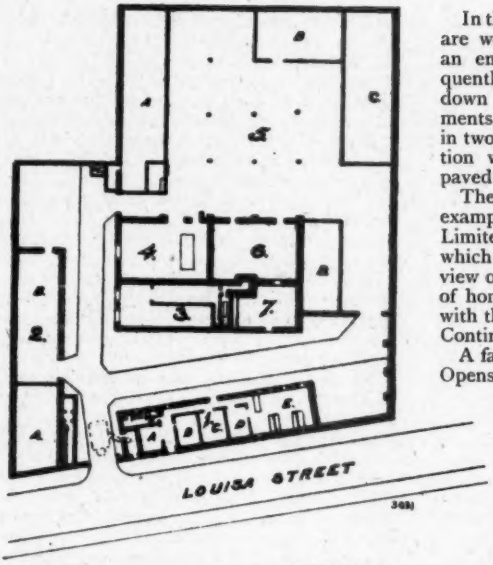


THE WORKS OF ELECTROMOTORS LTD.: VIEWS OF THE WINDING AND TOOL ROOMS.



THE WORKS OF ELECTROMOTORS LTD. :
THE STORE ROOMS FOR ELECTRICAL PARTS AND FINISHED MECHANICAL PARTS.

THE WORKS OF ELECTROMOTORS LTD.: GENERAL VIEW OF THE MACHINE SHOP.



1. OFFICES.
   a Lodge.
   b Waiting Room.
   c Manager's Office.
   d Secretary and Board Room.
   e Drawing Office and General Office.
   f Lavatories.
2. *a* Pattern Shop.
   b Casting Store and Pickling Shop.
3. BOILER HOUSE.
4. ENGINE HOUSE.
5. MAIN SHOP.
   a Winding Room.
   b Tool Room.
   c Stores.
   d Testing Department.
6. ELECTRICAL STOCK ROOM.
7. DINING ROOM.

a character as to be principally confined to differences in brush-holders, and that, therefore, the prime consideration governing the choice of any particular machine would be that of price. The like state of affairs exists, perhaps not quite to the same degree, in stationary engines and locomotives.

American engineers were the first to recognise the true significance of this, and to equip their shops with special tools, jigs, gauges, and templets, with the result that they thereby placed themselves in an advantageous position over their British rivals in the competition for the world's markets.

The stress of this competition, the spread of technical education, the vigorous campaign waged by the press during the last year or two, have not, however, been in vain, and signs are not wanting that our manufacturers are now beginning to realise the advantages to be secured by restricting manufactures to one or more types of output, although in many instances the difficulties of adapting old works to new conditions, the dislocation of business consequent upon removal to a new works, are elements which militate against any very rapid change taking place.

In the two examples chosen of works which are working on the new principles, one is an entirely new company and was, consequently, at liberty to select a site and to put down a plant exactly suited to its requirements, while in the other instance, a fire did in two hours what perhaps years of deliberation would have failed to accomplish, and paved the way for a fresh start on new lines.

The first of the two works selected as examples in specialisation is Electromotors Limited, Openshaw, Manchester, a company which was formed quite recently with the view of supplying a reliable and cheap motor of home manufacture, which would compete with the importations from America and the Continent.

A favourable site having been marked at Openshaw, a great engineering district of Manchester, a plot of ground 15,000 sq. yds. in area was secured for the purpose of building works specially adapted for the above object.

Plans were put in hand and the buildings proceeded with, under the direction of Mr. Joseph Nodal, engineer and architect, Manchester. In the meantime temporary premises were taken in Hulme, for the purpose of making the necessary experiments and to complete, as far as possible, the making of gauges, jigs, templets, in order that the manufacture might be proceeded with energetically immediately the necessary plant had been installed at the new works. Mr. Ben Longbottom was appointed works manager and Mr. T. M. Gribbon, secretary.

The removal from Hulme to Openshaw took place at the beginning of this year, and by the end of March everything was in full working order.

The plan shown above indicates the manner in which the works have been laid out, a point which, together with that of shop arrangement, is of prime importance.

The comparative lightness of motor parts and of the finished product rendered the problem of arrangement comparatively simple, but, as will be seen, the main object kept in view has been to allow the successive operations to be performed without the necessity of moving the work further than was necessary, and of permitting the successive stages of manufacture, from the rough castings store to the machine shop, finished mechanical parts and electrical parts, to be performed with a minimum expenditure of time and labour.

Referring to the plan, it will be seen that the offices are detached from the main building. They are well arranged, and com-

prise the main entrance, waiting room, works manager's office, secretary's office and board room, drawing and general offices, the two latter, in conformity with very recent practice, being merged into one.

The pattern shop, which is equipped with the most up-to-date wood-working tools electrically driven, and the castings store are situated in another detached building to the left of the offices.

The castings store is of ample proportions, the floor space alone being capable of accommodating 150 motor bodies. In addition there is a series of bins, each marked with the pattern number of a motor part and designed to store sufficient parts to complete the above-mentioned number of bodies. The bins in use at Electromotors Limited are not of the ordinary type; they consist of rectangular wooden boxes, which slide into the supporting frames. The lower edges of the boxes are faced with angle iron, as are the corresponding edges of the supporting frames, an arrangement which enables the box to be readily withdrawn. The weight of each box is known and marked, so that at stocktaking time all that is necessary is to weigh box and contents, afterwards deducting the weight of the former. A card is affixed to the front on which is recorded the total contents and the date and quantity of any material withdrawn.

The main building, the divisions of which are clearly marked on the plan, is surrounded by a roadway, and all goods are received and despatched from the far end of the works.

The steam-raising plant consists of a Lancashire-type boiler, made and erected by Messrs. Edward Heaton & Son, of Manchester, a 96-pipe Green's economiser, the scrapers of which are electrically driven. The engine-room, in which space has been provided for further additions, contains a 125-kilowatt Holmes generator, driven direct by a Browett-Lindley high-speed engine, and a switch-board by Messrs. Cowans, Ltd. The current generated is used for driving and lighting the whole of the works.

In the main workshop every method of drive is in use, the object of this arrangement being to demonstrate the special advantages of this system.

It is lighted by 32 arc lamps of the G.E.C. workshop pattern, incandescent lamps being provided where extra light is required. The arc lamps are arranged in zig-zag fashion to secure a maximum lighting with a minimum of shadows.

An accompanying cut gives a fair idea of the extent and arrangement of the machine shop, into which all castings are brought in from the pickling process which they undergo on removal from the castings store. The tools, which are generally speaking of English make, have been designed with a view of machining one class of article. Power is distributed to the heavier machines on the unit system, the method of application of the motor in this case naturally varying with the machine and the conditions under which it is being used.

The lighter machines—for example, light lathes employed in repetition work—are grouped on the multiple system, and are operated from motor-driven line-shafts—counter-shafts being used to secure any necessary difference in speed—some of which may be seen in the illustration. Each line-shaft is operated by a special motor, usually mounted at the shaft level on a bracket fixed to the nearest point of support, and inverted, if necessary. Where machines of standard pattern have been put in, special chucks and other appliances have been fitted to secure accurate and rapid production.

One of the most important features of the department is the abolition of the rule and callipers in favour of a system of gauges, templets, etc., whereby a maximum accuracy is secured in a minimum of time. For every type and size of motor three sets of gauges, etc., are provided—a standard set, which is retained in the tool-room for reference; another set, which is issued to the machinists with the castings; and a third set for the testing-room, where each part is again carefully measured before being assembled.

The tool-room, a view of which is reproduced, is equipped with every up-to-date appliance necessary for the making of the cutting tools and gauges.

Portable shelves are arranged for storage purposes, from which tools are issued as required. Duplicates are kept, and if a tool requires renewal it is brought back to the tool-room and another substituted for it, thus doing away with loss of time and making the department responsible for the maintenance.

One section of the main building is devoted to the electrical portion of the work, including brass-finishing, this section being in turn divided to screen off the female operatives (under the charge of a forewoman) engaged in the winding of field-magnet bobbins and preparation and taping of armature coils, etc.

An illustration shows a view of one end of the winding department, the special feature in which is the special winding machines, designed and made by the company. These machines, manipulated by girls, perform the winding operation very rapidly and in a manner unsurpassed in the writer's experience.

The armature and commutator building department is shown in another illustration.

A special room is set apart for the apparatus used for drying armature and magnet coils, which consists of a Passburg vacuum drying chamber in which the vacuum is maintained by a motor-driven air pump.

Up to this point all operations have been in connection with the manufacture of parts, and the two sides, electrical and mechanical, terminate in what is, after all, the chief feature of the system of the company—the electrical and mechanical stores for finished parts.

A study of the photographic reproductions of these stores will do more to impress the reader with the systematic arrangements in vogue at these works than perhaps an elaborate description. Every part of each size of motor, from a brush to an armature and from a pulley-key to a motor body, is there in a properly labelled and, where possible, sliding receptacle, and each room is in charge of an attendant, who receives finished parts from the main shops and issues them from stock to the assembling department on receipt of an order from the office. In designing the motor special attention was given to having as many machined parts as possible, thereby reducing the cost and time of fitting to a minimum.

The company is thus in a position to deliver motors practically from stock, and it is only a matter of from three to four days from the receipt of an order to assemble, test, and deliver a motor of any voltage.

In the view given of the assembling shop will be noticed several portable cranes, which, owing to the light character of the work manufactured, is the only method of lifting and carrying prevailing throughout the works.

The test plant, of which unfortunately it was impossible to obtain a view, was laid down at considerable expense, and provides, by an arrangement whereby the motors drive the dynamos that supply them with current, a means of testing up to 80 h.p., with an expenditure of only 15 h.p. from the works plant.

At present the manufacture is confined to continuous-current motors, of sizes ranging between $\frac{1}{2}$ to 15 h.p., but patterns are in hand for others extending up to 25 h.p., which it is the present intention to make a maximum, although alternating-current motors may become another feature later on.

Electromotors Limited is an object-lesson in specialisation, and it is difficult to conceive how it would be possible to reduce the manufacture of motors to a more systematic or economical basis. Certainly production on these lines should suffice to keep any semblance of a foreign-made motor out of this country.

(To be continued.)

❀ ❀ ❀

How Great Britain is meeting Foreign Competition.

Speaking of the restless enterprise of the Americans, Lord Rosebery recently remarked that in the New World the disdain of finality, the anxiety for improving the best, seemed almost a disease: but in Great Britain we could afford to catch the complaint, at any rate in a mitigated form, and give in exchange some of our own self-complacency. We needed to be inoculated with some of the nervous energy of the Americans.

Whilst endorsing Lord Rosebery's views, and largely sharing the opinions of other critics that our country has too long traded on its unique reputation, FEILDEN'S MAGAZINE deprecates anything which might tend to show that Great Britain is a decadent nation, and is not able to successfully compete with America or any other country. That the unprecedented progress which was made by this country in the past is not going to stultify the actions of our manufacturers is beginning to show itself pretty forcibly in the magnificent equipment of many new workshops throughout the United Kingdom; and whilst we shall continue to impress British firms with the necessity of constantly following the sage advice of Lord Rosebery, we cannot allow it to go forth that we have nothing but obsolete plants and ideas in this country. In a recent issue we started a series of articles, entitled "How Great Britain is Meeting Foreign Competition," and produced a profusely illustrated article written by an expert member of our staff, showing the up-to-date nature and completeness of a great North of England shop In this and succeeding issues we continue the series. The details should form object lessons of great value.

WORKSHOP PRACTICE

Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection. See important announcement in advertisement pages.

❀ ❀ ❀

Note.—One of our readers, a member of a manufacturing firm, whose name we omit for obvious reasons, has complained of some remarks made by one of our correspondents, and has asked for particulars of the apparatus mentioned, or for information as to where it was fixed. It will, perhaps, be sufficient if we remark that any statements made in this section by any of our correspondents are to be taken as the personal experience or the personal opinions of the particular writer. We do not hold ourselves responsible for the opinions of our correspondents, and while doing our best to see that all statements of experience or of opinion are made in good faith, we are unable to give either the name of our correspondent or any information that will lead to his identification, unless we have had instructions from our correspondent that he has no objection to our so doing. In the absence of any instruction that a correspondent does not object to his name being given we shall adhere to the rule given above.—ED.

A Unique Telephone Fault.—It was in the days when the telephone monopoly was in full force, and apparatus were designed to endeavour to avoid the patents held by the United Telephone Co. Nearly all of the receivers that were made at that time, and for the purpose of avoiding the Bell patent, were constructed with either a mica or membrane diaphragm, with a disc of iron secured to the centre of the diaphragm, instead of the whole disc being of iron, as with the Bell telephone. In one case which the writer had to deal with, a telephone gradually got dull in speech, and finally refused to speak at all. Examination showed that there was a sort of brush between the iron pole of the electro-magnet and the iron disc on the diaphragm. This brush was composed of very fine pieces, filings, of iron, which must evidently have been left in the apparatus when it was put together, but out of sight. The workman who put the apparatus together did not trouble to see that all filings were cleaned out. As he did not see any, he supposed that either there were not any, or that if there were it did not matter. The continual magnetising and demagnetising of the electro-magnet — the apparatus was worked without a permanent magnet — caused the filings to gradually work their way into the space where the magnetic flux was greatest, forming when there a bridge between the two sides of the magnetic circuit at that point, and effectually damping the vibrations of the diaphragm. The writer has not met with a similar case in any telephone receiver in which a permanent magnet is used with a complete iron diaphragm.

A Somewhat Similar Case, with an Iron Diaphragm.—This is another case, quite different to the above, and yet presenting the same features, while it is due to almost the same cause. It also occurred in the early days of telephone work, when telephonic apparatus were not as well made as now. A particular telephone apparatus that connected a cloth mill and the office in the town adjoining was reported to be working badly. Examination showed that all circuits were right, battery in good order, and yet the click of the telephone on short circuit was faint, muffled. Further careful observation showed that the diaphragm—it was an iron diaphragm in this case—was a little dented in the centre. The diaphragm was turned over, so that the dented portion was now outwards, the centre of the diaphragm being therefore farther from the pole of the magnet. The result was that speech became clear at once. The writer met with this trouble somewhat

frequently in the early days of telephone work, and in some cases it was necessary to regulate the diaphragm a little after reversing it. The cause was the diaphragm was deficient in resiliency—the ability to return to its original position after being drawn towards the pole of the magnet by the telephone currents (those which increased the attraction between the magnet and the diaphragm). The writer has not met with the trouble in recent years.

[NOTE.—As many of our readers will have had experience with telephonic apparatus under various conditions, it would be very interesting if they would give other readers the benefit of their experience. Old-time faults often turn up again in another form.—ED.]

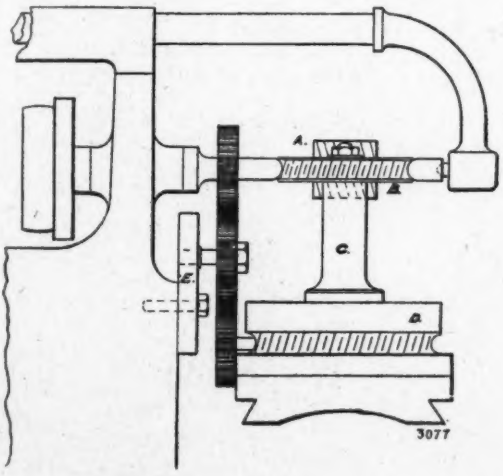
Wormhobbing Arrangement. — It is the usual practice in cutting worm-wheels to first rough-cut them with a suitable stocking cutter, and finally to finish cutting them with their own hob. This I found was somewhat slow, especially in the case of small wheels. The following is an arrangement I found rather convenient. The illustration is a Brown and Sharpe milling machine head. *A* is the worm hob, which is placed in the centre of the milling cutter arbor, *B* is the blank to be cut, *C* is the stud on which the blank is fastened, firmly held with usual nut and washer; the stud is screwed into the circular milling table *D*, which is again bolted to the table of the machine. Fixed by a feather on the cutter arbor near to the machine mandrel, is a change wheel; gearing into that is an intermediate one, which runs freely on a stud locked to an ordinary quadrant plate *E*, which has the usual adjustment. Fixed on the end of the shaft which gives the circular motion to the circular table is another change wheel, which completes the train, and then we can cut and hob any number of worm wheels at one operation.

"TOOLMAKER."

Fixing Loose Faces to Marine Cylinders. — Many sea-going engineers have had serious trouble and inconvenience by the bolts in the loose valve faces breaking or slacking back. These bolts are generally made of Muntz metal-rod, with cheese heads, and are screwed into place with an ordinary T-handled screw-driver. With this form of tool there is always a doubt as to whether the bolts are too slack or nearly twisted off, with the result that when the cylinder is heated up the face twists, causing leakage, and often a bolt or two is broken off. A simple and effective way of tightening all the bolts alike is by using a ratchet-brace and bit, as shown at Fig. 1. A piece of bar-iron *B*, cramped or bolted across the steam-chest, supports the end centre of the brace. For this job it may be an old ratchet-brace—useless for ordinary purposes—the wheel of which should be filed so that the teeth have equal angles on the sides; this allows the pawl to be adjusted so as to give a positive slip when a certain pressure is exerted. By this method the whole of the bolts receive a uniform strain. As a preventive to the bolts becoming loose through vibration, a slight notch is cut on the side of the recess, as at *A*, Fig. 2; and a "pop" with a centre-punch on the screw-head at *P* expands the edge sufficiently to prevent any movement, yet not holding the screw from withdrawal when leverage is applied. The ordinary and the modified form of ratchet-tooth are shown at Fig. 3.

E. FEWSTER.

Disc-Cutting for Nut-Closing Arrangement on Lathe.—The disc shown at Fig. 1 is the old style, as used on the early screw-cutting lathe for closing the nut upon the guide-



WORMHOBBING ARRANGEMENT.

screw when traversing the carriage along the bed. The old method of producing the slots *A A* was by cutting through the disc on a profiling machine with an end mill, the slots being sometimes diagonal, and in other cases radial slots eccentric with each other. An alternative is shown at Fig. 2, which consists of the disc being made double the thickness and grooved across, as *B B*, which is made equal in depth to about half the thickness of the disc. A number of slots may be planed out at a time by fixing the shanks in a jig on the planer-table and using a double or two single tools for the purpose. Fig. 3 is the improved method suggested by the writer to a firm making a large number of lathes, and was the one adopted as being the quickest and easiest. The shank end of the discs were fixed in a chuck carried on the lathe-spindle and holding a given number. A link, Fig. 4, was slipped over the shanks, with a nut on each, holding the discs from turning whilst the grooves were being cut. (£1 1s.)

G. W.

Making and Moulding Grate Lever-Fulcrum Pattern for Culm* - Burning Locomotive. — This piece of work, when bolted in position, does not appear anything beyond an ordinary casting ; but when the order is received for a pattern to be made, and the first introduction is in the shape of a blue print, the job looks a little more difficult than the casting, and at the first glance our thoughts wander in the direction of the moulder. In constructing a pattern recently for this detail, the following method was adopted with very satisfactory results. The end elevation and plan are shown at Figs. 1 and 2, and one-half the core-box at Fig. 3. The timber out of which the cheeks *C C C* were formed was first planed to the thickness and temporarily sprigged together, set out, sawn, finished, and then screwed to the base *B*. In order to avoid the facings *F* on the cheeks being left loose, the spaces between them were fitted with core-prints down to the centre line of the facings and extended beyond the length of them at each end, the core also leaving a thickness of metal, as sectioned on core-box

* Slack coal.

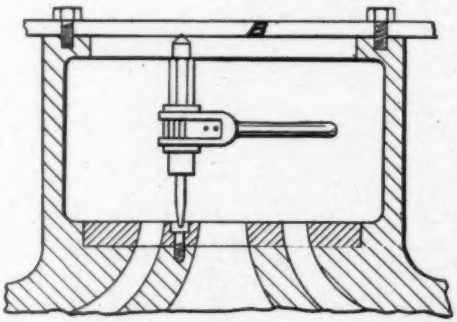


FIG. 1.

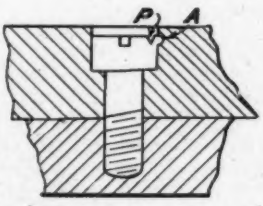


FIG. 2.

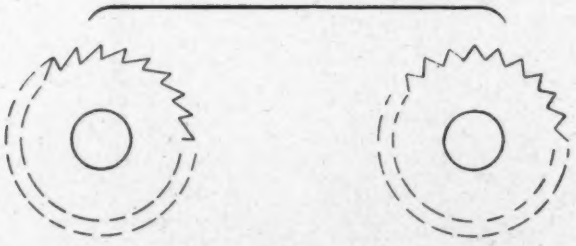


FIG. 3.

MARINE CYLINDERS.

at Fig. 3. To facilitate the moulding and assist in making a proper joint, a false top part, or joint-saddle, was made, as shown on the top right-hand of Fig. 1. This was made by sawing two sides out of 1½-in. timber, fixing them on battens and lagging them across with staves, so that the outline coincided with the top side of the pattern. By this arrangement the moulder was saved the trouble of bedding in the sand, as by laying the pattern on the saddle, which rested on a turn-over board, the bottom part moulding box could be inverted and rammed up, the saddle removed, the joint prepared with parting-sand, and the top part, or cope, rammed up, thus forming the greatest portion of the mould in the bottom box, with good bearing surfaces for the cores.

W. NEWTON.

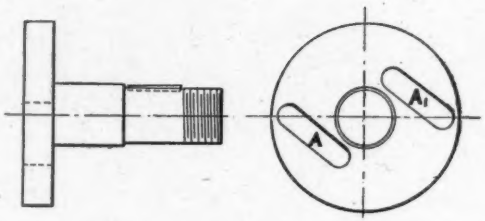


FIG. 1.

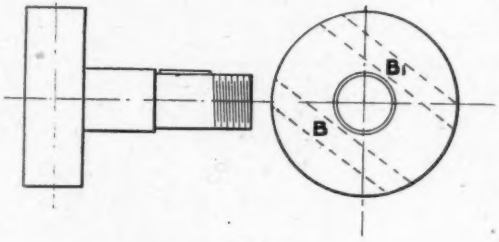


FIG. 2.

The Use of a Micrometer Gauge in the Adjustment of Large Bearings.—The adjustment of large bearings is an operation requiring considerable skill and ability to carry out successfully, so that any aid towards it is helpful. Perhaps to many the use of a micrometer in this work will be thought rather a useless luxury, but the advantages accruing from its use are too great to despise it when its use is known. As the material used in their manufacture varies considerably, and the working conditions of no two bearings are alike, the amount of slack a particular bearing may be run with, to give the best results, can only be found by actual experience. It is necessary that a means be adopted for ascertaining the amount of slack a bearing will run at. Supposing we have, say, a large crank-head, which, after adjustment, has been found to give every satisfaction, and we are desirous of preserving for future reference the amount of slack it is working with, so that on refitting at some future date it may be set to the same conditions which have been found to give the best results. We must first remove the cap of the bearing whose slack we are going to measure, taking care to mark the position of the nuts, so that we

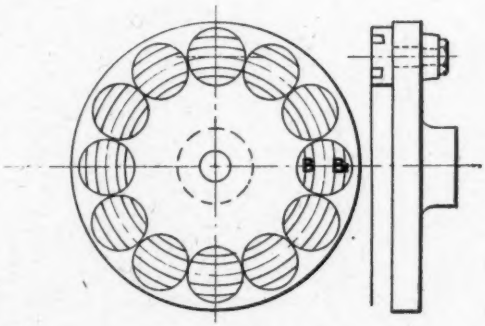


FIG. 3.

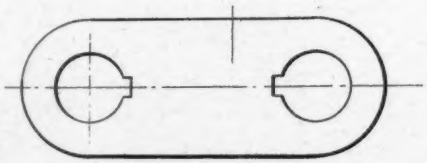


FIG. 4.
NUT-CLOSING ARRANGEMENT.

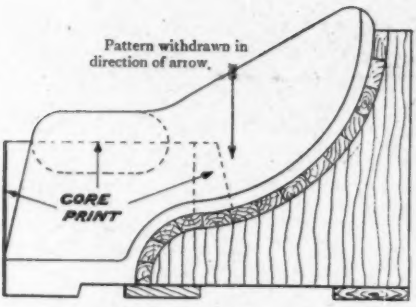


FIG. 1.—GATE LEVER FULCRUM.

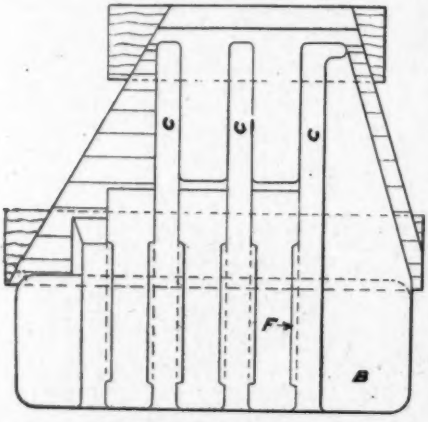
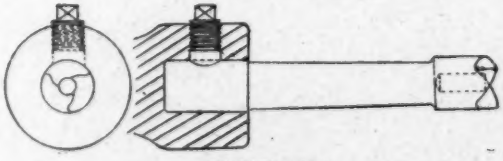


FIG. 2.—GATE LEVER FULCRUM.

FIG. 3.—GATE LEVER FULCRUM.



KEY-SEATING TOOL.

can make certain of screwing up again to their working position. On the cap being removed we take a length of soft lead wire about $\frac{1}{16}$ in. thick, and lay it in the crown of the brass parallel to the axis of the shaft, having removed one-half of the bearing for this purpose. When the wire is in place the brasses can be put together again, and screwed up with the nuts to the working marks. On taking out the wire, which has become flattened, and measuring this with a micrometer gauge, the exact amount of slack the bearing is working with is accurately ascertained, and can be noted in a book kept for that purpose, which, with the date it was taken, will form valuable information for future reference, giving exactly, on taking a lead at a later date, the amount of wear for a given period. It may be necesssary to point out that leads must be taken on the side opposite to the one carrying the weight; with the crank-head of a vertical marine engine the wire is placed between the lower brass and crank-pin, for the crank-shaft bearings between the shaft and top brass.

A. E. WARD.

The Key-Seating Tool shown at Fig. 1 should be made from good tool steel, and turned up to a diameter at the cutting end to coincide with the width of the keys in general use, terminating in a parallel or taper shank to suit the machine chuck. Three cutting edges are formed by milling away and "backing off," after which the tool is hardened. Beside cutting key-seats, it may be employed for slotting cotter bolts, connecting rod straps, ends, etc., and will be found an improvement over the general type of cutter having two edges, being steadier and more uniform when cutting.

H. O. DIXON.

The Proprietors of FEILDEN'S MAGAZINE desire to announce that, with a view to providing its large circle of readers—already, it can be safely said, the most extensive of its kind in the world—with an increasingly valuable production, they are arranging for important changes in the New Year along the line of progress.

Owing to the advancing demand for copies, Subscribers are advised to book up early to ensure complete volumes.

INDUSTRIAL PROGRESS

ENGINEERING NOTES AND COMMERCIAL INFORMATION

FROM ALL SOURCES.

Longevity of Beech Sleepers.—A very satisfactory result has been obtained on various railway lines by using creosoted beech sleepers. On two lines in Alsace-Lorraine beech sleepers were laid down experimentally in 1868–9, and 86 per cent. were still fit for use in 1897. In the Elberfeld district about the same result was obtained, only 13 per cent. of the beech sleepers laid down thirty years ago, had to be removed, the others being still, after this long period of wear, in good working condition. On the Eastern of France Railway, after being in use twenty-one years, only 6·4 per cent. of the creosoted beech sleepers had to be removed in 1892; while 26·7 per cent of creosoted oak sleepers were found unfit after the same period of time, and of untreated oak sleepers 52 per cent. were found to be unfit for service. During a period of twenty-four years on the same railway only 12 per cent. of the creosoted beech sleepers had to be removed, against 45 per cent. of creosoted and 67 per cent. of untreated oak sleepers; while the cost was three francs sixty centimes and six francs respectively. A German railway expert attributes this longevity of beech sleepers to the fact that beech wood absorbs far more creosote than oak, a thoroughly dry beech sleeper absorbing from thirty to thirty-five kilos, *i.e.*, an average of 72 lbs. under pressure.

Arc Lamp Improvement.—In a paper recently read before the International Society of Electricians in Paris, M. Laporte described some experiments made, with the object of ascertaining the efficacy of the Bremer arc lamp, the novel features in which are:—(1) the arrangement of the carbons, *i.e.*, they appear to be nearly vertical and parallel, but, in reality, form a very acute angle; (2) the composition of a material for electrodes in which, it seems, a metallic salt (or metallic salts) is mixed with pure carbon and with another substance (corine or fluorine?) by means of which the scarified secretions of the salts are softened and made to drop off periodically, instead of forming an incombustible coating which would eventually smother the arc; (3) the device for regulating automatically, by the intensity of the current, the arc under the influence of a magnetic field; and (4) the use of a special positive carbon, the exact composition of which is as yet unknown. This special positive carbon has in a 43 to 45 volt and 9-amp. lamps, a diameter of 7 mm., while the negative electrode is a Siemens carbon of 6 mm. diameter. While the Siemens carbon has a resistance of from 8,300 to 9,400 microhms centimetres, the resistance of the material for the special positive carbon amounts to 12,300 microhms centimetres. The colour of the Bremer arc is peculiar, lying between that of an incandescent light and an ordinary arc light without globe. The consumption of watts per candle-power, as proved by photometric tests, in the Bremer arc lamps is little more than one-half of that in ordinary arc lights, the exact ratio being 117 ÷ 200. Referring to this result of his tests, M. Laporte says: "It cannot be denied that these figures are favourable to the Bremer lamp, but there remains one point still to be elucidated, namely, whether the cost of the material for the special electrode may not affect the advantages shown by the photometric tests."

The Latest Alpine Railway.—Within the remarkably short period of two years the interesting mountain railway from Fayet-Saint-Gervais to Chamonix has been completed, and on July 25th, during the present year, it was opened to traffic. The total length of the line is 19 km., with a width of track of 1 m., and there are three very heavy gradients between the two terminal stations. There are two hydraulic power-stations to supply current for the trains and for lighting the railway stations, one of them is situated near Sérvoz, while the other is at Pont-Télissier. This equipment consists of four continuous-current dynamos of 200 kilo-watts each, supplied with power by a centripetal turbine. There are, moreover, two emergency dynamos of 40 kilo-watts each. For the ordinary purposes three dynamos only are required. Besides the terminal stations at Fayet (580 m. above the sea) and Chamonix (1037 m. above the sea), there are four other stations, namely, Chedde, Sérvoz, Les Hoches, and Les Bossons. In reality, this electric mountain line is but a continuation of the normal-track line from Cluses to Chamonix, for which in 1886 the Paris-Lyons and Mediterranean Railway Co. obtained a concession, but which was never carried beyond Fayet-Saint-Gervais, where the electric line now begins. There are, for the present, seven trains running on the latter, each consisting of four elegantly furnished cars of the Auvert type, with compartments for first and second-class passengers, each car having 32 seats and being provided with two electric motors, and being heated as well

as lighted by electricity. By means of a special motor the driver has perfect control over all the cars, while there is also a compressed air brake within his reach. The track consists of the two ordinary rails and of a third for the return current, which at low level crossings is replaced by a subterrannean cable.

Our Shipbuilding Record.—To judge from the data given in "Lloyd's Register of Shipping" with regard to our shipbuilding activity during the last three months, Great Britain is not yet quite as effete as our transatlantic contemporaries would like us to believe, and the increase which the figures given below represent, taking it together with similar progress in other industries, may be confidently interpreted as a sign that we are on the way again and are trying to make up for lost time. The number of such vessels under construction at the close of the quarter ended September 30th was 477, and the gross tonnage was 1,414,120, being an increase of 25 vessels and of 210,112 tons gross on the corresponding quarter of last year, and an increase in tonnage of 105,000 compared with the last quarter. During the quarter 197 vessels, of 496,088 gross tons, were commenced, and 159 vessels, of 430,425 gross tons, were launched. The greater number of the vessels under construction are for British owners. Of the 477 ships, 18 are of 10,000 tons and over. The number of ships, excluding warships, under construction in Great Britain and in France, Germany, Italy, and the United States are, according to the latest returns:—

Country.	No. of Ships.	Gross Tonnage.
United Kingdom... ..	477	1,204,008
United States	64	232,526
Germany	57	198,570
France	52	142,915
Italy	31	64,997

During the past quarter there were 50 warships under construction in Great Britain, of 375,045 gross tons. Of these. 41, of 353,670 gross tons, were for the British Navy, including 11 first-class battleships and 16 armoured cruisers. Of these 41 ships, 17 were being constructed in Royal dockyards and 24 of them in private yards.

Electrical Drying of Wood.—We herewith give to our readers the following recipe for simply drying green wood for building purposes, contained in a report of the United States consul at Reichenberg, Austria, recently sent to his Government:—The green wood is placed in a large wooden trough, the bottom of which is covered with a lead plate which is connected with the positive pole of an electric battery, and the trough is covered with another lead plate forming the negative pole. The wood is then subjected to a bath in a solution compound of 10 per cent. resin and 75 per cent. of soda. When the current passes, the sap is drawn out of the wood and rises to the surface while the solution takes its place. This process is permitted to continue from five to eight hours, after which the wood is removed and allowed to dry for about two weeks, and is then ready for building purposes. The drying can be considerably shortened by using artificial heat.

Water-tube Boilers.—The French Government has recently been experimenting with the Montupet water-tube boiler, but the results obtained have not been published. One important feature of this type of boiler, however, has, according to the "*Mittheilungen aus dem Gebiete des Seewesen's*," become known as the result of previous trials, namely, that the tubes of the Montupet boiler can be removed and replaced in a remarkably short space of time. On one occasion, during a trial lasting over four hours, the fires were reduced, the steam pressure lessened, the boiler emptied and a tube removed. All this was accomplished in a quarter of an hour. Upon the tube afterwards being replaced, the steam pressure was restored almost instantly. The total interruption, from the reduction of the fires to the restoration of the boiler to its proper working condition, occupied 40 minutes, of which less than ten sufficed for removing and replacing the tube. When the fires were out and the boiler had cooled, 32 tubes were removed within an hour and twenty minutes.

Road Improvements.— Our trans-atlantic kinsmen owe a good deal of their success to their knowledge of human nature. They are well aware that example is far more effective than precept. For this reason they are always ready to give a practical demonstration of the usefulness of what they desire to introduce among those to whom it is new. As an example may be mentioned the efforts of several railway companies to induce, by constructing specimen roads, the population living near their lines to build suitable highways for heavy wagons, for in this way the goods traffic of their lines would become considerably increased, while the farmers themselves would also derive considerable profit. Taking it all in all, there is perhaps no civilised country in the world which is so poor in good roads than the United States, in striking contrast to the excellent roads in many parts of our great North American Dominion. Anyone who, after having spent some time in the States of Washington or Oregon, for instance, crosses over to British Columbia and visits the Island of Vancouver, cannot help being struck by the difference of roads. The roads in the neighbourhood of Victoria, for instance, are a conspicuous monument to the enterprise and ability of the late Governor Douglas, almost as conspicuous as the law and order prevailing in this part of our Empire compared with the lawlessness of the Western States of the neighbouring Republic, or the status of the native Indians and their treatment contrasted with the unfortunate condition of the Indians who are left to the tender mercies of the Indian agents in the United States. Canada, it cannot be denied, is what Americans are apt to characterise as "slow," and, excepting in a few towns, its inhabitants appear to lack the energy of their enterprising neighbours. On the

other hand, however, they know nothing of those daring and often rather doubtful methods practised for the object of securing wealth, which, in a large percentage of cases, leads to failure and beggary, or to the even more dire fate of having to spend the most promising years of life within prison walls. On the whole, notwithstanding their "slowness," there is yet much to learn from Canadians for their neighbours, and above all, as regards good government. As regards roads, the lesson has begun to bear fruit, and, as above said, the railway companies have commenced a practical propaganda. "The Good Roads Special Train, which the Southern Railway is sending over its system as a missionary enterprise," says the *Engineering Record*, "has twelve cars, a full equipment of road-building machinery, and a staff of eighteen men, including Mr. Martin Dodge, of the office of Public Road Inquiries, and President W. H. Moore, of the National Good Roads Association. The train will stop at about a dozen leading Southern cities, and a practical demonstration will be made at each of the method of constructing roads suitable to the locality. Such trains have already been run over the Illinois Central and the New York Central, with good results in the way of increased interest in good highways.

Improved Steam Boilers. — An interesting device for increasing the water-circulation and steam capacity of steam boilers, and for effecting a considerable saving in fuel, has been patented recently by Mr. Edward Williams-Wynne, of Liverpool. It consists essentially of a nest of tubes of suitable diameter, expanded or otherwise fastened into a box, or apparatus, which is inserted into the furnace of the boiler and run from end to end of it in a horizontal or, if circumstances render it advisable, inclined position. Through the nest of tubes enclosed in the box, which are suitably connected to the boiler and boiler-furnace by means of pipes, the water will circulate under conditions that facilitate its speedy conversion into steam. The introduction of this device will, it is expected, greatly reduce the expenditure for fuel, and will, according to the inventor's statement, enable an ordinary tubular or cylindrical boiler approach in steaming capacity to the average water-tube boiler, with the additional advantage of being free from the defects of this latter type.

"Science Abstracts."—We are pleased to be able to announce the appointment of Mr. G. W. de Tunzelman, B.Sc., M.I.E.E., to the editorship of that useful publication, indispensable to all interested in the progress of physical science, "Science Abstracts." The journal, which is issued monthly under the direction of a joint committee of the Institution of Electrical Engineers and the Physical Society of London, will, on and after January 1st, 1902, be published from these offices. Until that date it will continue to be published by Messrs. E. & F. N. Spon, 125, Strand, London, W.C.

Dynamite Detonator.—A detonator for dynamite has been invented by M. Aubert, of St. Etienne, France. It is intended for use in coal mines where gas is present in dangerous volume, and it is operated without the use of electricity. A copper tube receives the end of the fuse for several inches, and at the other end of this tube is a percussion cap similar to those used in toy pistols. This cap lies against the side of the tube, which is there pierced by a small hole, and the fuse end is only '07 in. from the cap. The end of the tube containing the cap is inserted into another copper cylinder containing the firing mechanism. To operate the apparatus the outer tube is held in the hand and a smart blow on a button explodes the cap; the gas from the burning fuse fills the cylinder, but is prevented from escaping outside by the metallic gauze which covers the openings of it.

Overhead Cables.—A remarkable work is described in a recent issue of the "Scientific American." It consists of four cables spanning the straits of Carquinez, between the Solano and Contra Costa Counties of California. The horizontal span between the towers supporting the cables is 4,427 ft., and the height at the centre above the water is 206 ft. The cables, of which there are four, are used for conveying electricity across the straits. The voltage on the line is 40,000, and the insulators weigh 50 lb. each. The cables are built up of 19 plough steel wires, and measure externally about $\frac{3}{4}$ in. in diameter. The tension on each cable at the towers is about 10 tons.

The Mineral Resources of Brazil.—According to the "Engineering and Mining Journal" the mineral resources of Brazil are not confined to the gold and diamonds which are generally credited to that country. The properties described, though but partially developed, show great possibilities in the line of iron and steel manufacture. Moreover, there are other deposits of iron ore, that are not yet exploited, but present indications of probable value. It is quite possible that in the future, Brazil may take the leading position in South America as a manufacturing country, which its great resources seem to warrant.

Correction.—In the note on the Glasgow exhibit of the British Westinghouse Company, published in our last number, it was stated that the car shown in the Westinghouse Pavilion is "fitted with Milnes' electro-magnetic slipper brake." We are informed that Messrs. Milnes of Birkenhead were the builders of the car body. The electro-magnetic brake fitted is of Westinghouse manufacture, and is known as the Westinghouse Magnetic Brake.

Personal.—We understand that Mr. W. P. Butterfield, of Shipley, Bradford, Yorks, has been awarded the contract for supplying the sanitary dust-bins which the Bradford and Blackpool Corporations recently decided to adopt.

In this section is presented every month a concise précis of the contents of the leading organs of the technical press and of the proceedings of the learned societies throughout Great Britain, the Continent, and America, and also, in a summarised form, the subject matter of the more important articles appearing therein.

With few exceptions copies of the articles referred to in this section can be supplied by us. Price 1s. 4d.

ARCHITECTURE AND BUILDING.

1. Construction and Design.

Caisson Foundations.—*Pneumatic Caisson Foundations of the New York Stock Exchange Building.* The article enters into a detailed description of the construction and putting in place of the pneumatic caisson foundations on which will rest the concrete piers that are to support the various columns of the stock exchange building referred to. These columns comprise wall columns running along all sides and interior columns arranged in three longitudinal and six transverse rows, spaced 20 to 35 ft. apart on centres. The building itself will be an eight-storey fireproof structure with an approximately rectangular main part about 150 ft. deep, with 138 ft. and 133 ft. fronts on Broad and New Streets, New York, respectively, and an irregular extension about 84 ft. long with a 15-ft. front, giving a Wall Street entrance.—*Engineering Record*, Sept. 28th, 1901, pp. 289-92. (Ill.)

Power Houses.—*The Power House of the Bristol Railway.* The article contains a description of the fireproof steel building, having a length of 140 ft., a width of 50 ft., and a height of 116 ft., which was erected as power house for the Bristol Tramways and Carriage Company's electrical plant at Bristol, England, constructed by the River Canley Manufacturing Company at Pittsburg, U.S.A., and erected on British soil by American employees sent for that purpose to England.—*Engineering Record*, Sept. 21st, 1901, pp. 277, 278. (Ill.)

CIVIL ENGINEERING.

1. Bridges and Viaducts.

Bridges.—*Mill Creek Bridge, Cincinnati.* Description of a plate girder through bridge about 80 ft. high, carrying a heavy city traffic across the Mill Creek, Cincinnati, and very interesting on account of special features of construction and the dimensions of the two main girders, which are 213 ft. long over all, which gives a clear span of 199 ft. between abutments, a distance probably greater than that of any other bridge-span in the world.—*Engineering Record*, Sept. 28th, 1901, pp. 293-5. (Ill.)

—— *Rolling Lift Bridges.* By Walter Fawcett. The author discusses the salient features of the rolling lift bridges which have been constructed during the past few years in Chicago and elsewhere in the United States, and which form so distinct an advance over the types of movable bridge structures erected previously that engineers in other countries, who are unanimous in their appreciation of their excellence, are preparing to imitate them. In fact, Americans have successfully solved a problem which European engineers have wrestled with in vain—namely, how to accommodate the highway traffic over congested waterways, such as the Thames.—*Scientific American*, Sept. 28th, 1901, pp. 198, 199.

—— *The Architectural Treatment of Bridges.* By the Editor. The article is accompanied by three bridge designs, one by an engineer and two by architects specially selected for the purpose of discussing with reference to them the treatment of bridges from an architectural point of view—*i.e.*, the degree and manner in which, after the purely structural requirements have been worked out, a bridge may be regarded and treated as a work of art, susceptible of architecture, effect, and embellishment.—*Builder*, Oct. 5th, 1901, pp. 284-6. (Ill.)

Plate Girder Bridges.—*Collapse of a Long Plate Girder Bridge.* The article contains the account of an accident which occurred in France on July 17th, when an emergency bridge span, such as the French Army Engineer Corps keeps on hand in various sizes, and which had been fitted on a masonry arch bridge over the Adour River, at Tarbes, France, to replace a part of the stratum washed away by a flood, collapsed, and fell into the river, one of the girders breaking in two, and both being badly twisted. The conclusion of the engineers present being that the top flange of the up-stream girder began to buckle at the point of maximum flexure, about 65 ft. from the loaded end, and first snapped the heads of the two rivets through it, as the vertical lock stiffened them, and the increasing lateral deflection broke the rivets in the web stiffener and the transverse struts, and warped the girder till it buckled out and collapsed, bringing the down-stream girder with it.—*Engineering Record*, Sept. 21st, 1901, pp. 281, 282.

Framed Arches.—*Kinematic Theory of Framed Arches.* By Prof. Ramisch. The author applies kinematic analysis to determine forms which are statically indeterminate.—*Zeitschrift des Oesterr. Ingenieur-und-Architekten Vereins*, Sept. 6th, 1901, pp. 595-8. (Ill.)

2. Canals, Rivers, and Harbours.

Canal Construction.—*The Dortmund-Ems Canal.* Abstract of the more important portions of a paper by Mr. Hermann, read at the recent International Engineering Congress at Glasgow, in which the author describes a number of novel features of considerable interest to engineers engaged in canal work.—*Engineer*, Oct. 11th, 1901, pp. 313-21.

ELECTRICAL ENGINEERING.

1. Theory.

Alternating Current Phenomena.—*Application of Grassmann's System of Quaternions to the Analytical and Graphic Treatment of Alternating Current Phenomena.* By Franklin Punga, of Dresden Niedersedlitz. This is a very lucid article on a subject rarely treated with the same clearness and simplicity in the text-books, and will be of considerable assistance to practical electricians, who will find probably some difficulty in perusing Grassmann's original treatise, "Die Ausdehnungslehre," owing to its semi-philosophical form, while there can be

no doubt that Grassmann's method is of great value for the theory of electrical engineering.—*Zeitschrift für Elektrotechnik*, Oct. 20th, 1901, pp. 505-8, and Oct. 27th, pp. 516-20.

Sources of Electricity.—*Electricity Direct from Coal.* Abstract of a paper by Regierungs-rath Dr. Weber, read before the Berlin Local Branch of the Society of German Chemists, in which the author discusses the famous problem of an eventual supply of electrical energy direct from coal. The author, after having dwelt on the enormous importance which the successful solution of this problem would have for the whole civilised world, here points out that a great number of the inventions of the nineteenth century at one time seemed similarly impossible as this above, and he for one would certainly not adm t that sufficient proofs had been brought forward to render ultimate failure a foregone conclusion.—*Elektro Techniker* Oct. 15th, pp. 253-5.

2. Electro-Chemistry and Metallurgy.

Batteries.—*A New Primary Battery.* Concise account of a primary battery in which compressed air, preferably heated, is used as a depolarizer, patented by La Société d'Etude des Poles Electriques.—*Electro-Chemist and Metallurgist*, Sept. 1901, p. 217. (Ill.)

Electro-Metallurgy.—*Electro-Metallurgy at the Glasgow Exhibition.* Short reference to a few scattered exhibits at the above exhibition which, though not classified as such, are connected with this branch of electro-chemistry. Among these are mentioned the nickel exhibit of the Orford Copper Company, of Sudbury, Ontario, Canada, and an exhibit of nickeliferous pyrrhotite, together with chalco-pyrite, also from Sudbury. Specimens of single-blow Bessemerised copper-nickel matte exhibits by the Canadian Copper Company are mentioned, and a collection of tubes and rods tested in various ways is referred to among the products of the Orford Copper Company.—*Electro-Chemist and Metallurgist*, Sept. 1901, p. 220.

New Material.—*Orlyte—a New Material.* Under the above title reference is made to a material discovered by Professor Orlowsky during his researches into the best way of reducing the excessive hydroscopic properties of carbide of calcium. After having tried a great number of methods for impregnating the carbide without success, he decided to drop the pasty mass as it comes from the furnace into a mixture of natural tar and mazont or astatki, the proportions and application of which are patented. The first experiments of this kind were made at the works of Roessler & Halske, in Frankfort-on-the-Maine, and later followed by experiments made by the Compagnie Générale d'Electro-chemie, in France. The material thus discovered is said to yield from 300 to 310 litres of acetylene per kilogramme, and the latter gives a brighter and more perfect flame which, it is suggested, is due to the evaporation of hydro-carbons during the formation of the gas. Last, but not least, orlyte is not hygroscopic.—*Electro-Chemist and Metallurgist*, Sept. 1901, p. 222.

3. Measuring Instruments and Methods.

Voltameters.—*A Voltametric Balance.* By Dr. W. Pfanhauser, jun. The author of this contribution having found in practice that the current methods of determining the weight of the metal precipitated in an electrolytic bath are either too inaccurate—as, for instance, where precipitates of gold, silver, or other precious metals are in question—or they are too inconvenient and require too much time, has designed a voltameter in the form of a balance, by which it is possible to determine the equivalent amount of copper in the voltameter without being obliged to dry first the cathode of the voltameter (for weighing the air) and to lift it out of the solution. This improvement was obtained in a simple manner by transforming the voltameter into a balance. The balance beam receives the current, and the arrangement is such as to have the circuit automatically interrupted when the balance beam stands at zero. An electric bell connected with the apparatus indicates this interruption, advises the experimenter of the fact that the requisite number of amp.-hrs. has elapsed, and that the electrolytic process has come to a stop. This novel voltameter is to be obtained from the firm of Wilhelm Pfanhuaser, Berlin and Vienna.—*Zeitschrift für Elektro-chemie*, Oct. 10th, 1901 pp. 923-7. (Ill.)

4. Dynamos, Motors and Accessories.

Electrical Plant.—*Electric Machinery at the Glasgow Exhibition*, No. V. The article describes the most striking exhibits of the British Schuckert Company, which, as the author remarks, stands *facile princeps* among the large number of really excellent electrical exhibits, as might be expected from a company the parent firm of which, at Nüremberg, built the first dynamo in 1875, has large works at Berlin and Vienna, has covered an immense area with the greatest variety of electrical machinery and apparatus, and, with the possible exception of Siemens and Halske, has the ripest experience of all electrical manufacturing firms in the world.—*Engineer*, Oct. 11th, 1901, pp. 372, 373. (Ill.)

5. Electric Transmission of Power.

Water Power.—*Water Powers of the Springfield, Mass., United Electric Light Company.* By Alton D. Adams. The utilisation of water power for developing electric energy offers an excellent illustration of the growing importance of energy from waterfalls transmitted to centres of population, and the Springfield system shows, as also do those of Hartford, Conn., Manchester, N. H., and other cities of New England, that it is not always essential to derive the power from some big falls at a great distance, but that very satisfactory results may be obtained from near by smaller powers, and their subsequent combination.—*Electrical World and Engineer*, Sept. 28th, 1901, pp. 495-500. (Ill.)

6. Electric Lighting.

Electric Street Lighting.—*A New Lighting System.* By Joseph Löwy. This article deals with a novel system of street lighting, by means of which it is possible to have lamps which remain lighted throughout the night, and such as are in use only during half that period, connected in the same circuit, and yet to extinguish the latter from the central station without a separate switch being required. The system is the patented invention of Mr. Czeczowiczka.—*Zeitschrift für Elektro-technik*, Oct. 20th, 1901, pp. 503-5.

Electric Lamps.—*The Cooper-Hewitt Paper Lamp.* This lamp attracted considerable attention last spring at the Conversazione of the American Institute of Electrical Engineers, but its construction was at that time known in part only, owing to patents pending. Since then, however, ten patents have been granted and issued, and an article based on the text of these patents, which together cover all the details, appears in the paper given below describing what may justly be called one of the most interesting novelties in electric lighting.—*Electrical World and Engineer*, Sept. 28th, 1901, pp. 503-9. (Ill.)

7. Telegraphy and Telephony.

Telephone Switchboard.—*The Kellog Telephone and Switchboard Exhibit in the Pan-American Exposition.* The article describes, among other features of the exhibit, a switchboard, of which a section was shown. This switchboard is the largest centralised energy multiple switchboard ever built, having an ultimate capacity of 12,000 subscribers' lines, and being provided with line-lamp signals, and double-lamp supervisory signals in the cord circuits. A unique feature is the simplicity of the spring jacks, which are provided with only two terminals, and are mounted 40 per strip on ¾-in. centres, thus greatly reducing the area occupied by multiple jacks on the face of the section, and rendering the cabling very simple both as regards wiring and maintenance.—*Electrical Review*, October 26th, 1901, pp. 524-6. (Ill.)

8. Materials and Methods for Conducting Currents.

Return Circuits.—*The Best Manner and Mode of Conducting the Return Circuit to the Power House.* By E. G. Connetti. Under the above heading is published a paper by the author mentioned, read at the twentieth annual convention of the American Street Railway Association, held in New York City, October, 1901.

In this paper Mr. Connetti endeavours to demonstrate that the best manner and mode of conducting the return circuit to the power house is to use practically a jointless and independent metallic return, connected to each rail in which the connection is made with ample surface contact and absolutely watertight, so as to avoid the chemical action which is likely to take place between the copper rivet and the steel rail. For this purpose the rivet should, he says, be covered with a thick coating of lead, solder or tin.—*Electricity* (N.Y.), October 23rd, 1901, pp. 231, 232.

9. Electric Traction.

Electric Railways.—*Chicago-Joliet Electric Railway.* Description of one of the most important of the suburban electric railway lines which form a network of ever-increasing dimensions around the great Western metropolis. This line, which has just been opened to traffic, runs from Joliet in a north-westerly direction through the Desplaines Valley to the south-western limits of Chicago, at Archer and Forty-Eighth Avenues, paralleling much of this distance—30 miles—the Chicago drainage channel and several steam rail-road lines.—*Western Electrician*, October 5th, 1901, pp. 218, 219. (Ill.)

Electric Traction.—*High-Speed Electric Traction in Germany.* By O. Lasche, Berlin. The author of the article published under the above heading is the chief engineer of the Allgemeine Electricitäts Gesellschaft, of Berlin, who has dealt with the same subject also in a paper read before Section 9 of the recently-convened International Engineering Congress at Glasgow. The present contribution deals exclusively with the construction of a motor car by the A.E.G. for the high-speed trials inaugurated by the committee of inquiry recently appointed at Berlin for the purpose of ascertaining the technical and economical requirements of high-speed electrical working on long-distance railways. Messrs. Siemens & Halske are the only other German firm that has received an order for a similar car. The maximum speed limit for the trials is to be 200 kilometres (125 mls.) per hour, and the German war department have placed their completed electric railway line between Berlin and Zossen at the service of the committee. The car of the A.E.G. was tested with a peripheral speed of the wheels of about 56 metres per second (corresponding to a car speed of from 200 to 210 kilometres per hour), and the trials at the factory answered all expectations, promising to fulfil all the conditions laid down by the committee as far as it is possible to judge from stationary tests.—*Engineering*, Sept. 13th, 1901, pp. 369, 370.

Electric Tramways.—*The Munich Surface Contact Tramway.* The article refers to the interesting exhibit at the Schuckert pavilion in the Glasgow Exhibition illustrating the system of surface contact tramway which, after somewhat prolonged experiments at their works in Nürnberg, they have laid down at a trial length of 600 metres (2,000 ft.) in the Goethestrasse, in Munich. The original design has since been greatly modified, for the trial line laid down in 1896 proved to be unsatisfactory, the switches stuck, and one day, during a thaw following a snowstorm, a stud, which was left charged owing to such sticking, caused the death of a horse. The authorities, in consequence of this occurrence, forbade further trials in the streets of Munich until the whole system should have been revised and new safeguards introduced. Such a revision has since taken place, and the electro-magnets operating the switches, which heretofore were excited by the main working current, are now operated by a shunt off the main current, an obvious and very important improvement.—*Engineer*, Oct. 25th, 1901, pp. 423-4. (Ill.)

High-Speed Traction.—*The Zossen Polyphase Railway Installation for Experimental Trials with Speed up to 125 Miles an Hour.* By Walter Reichel, chief engineer of the Siemens and Halske Co. Continuation of an article on the subject, describing the electric equipment of the car built by the firm, being one of the two cars selected by the committee in charge of the trials.—*Electrical World and Engineer*, October 5th, 1901, pp. 572-74.

Transformers.—*The Zossen Polyphase Railway Installation for Experimental Trials with Speed up to 125 Miles an Hour.* IV. By Walter Reichel. In the portion of his contribution here reproduced, the author, chief engineer of Messrs. Siemens and Halske, describes the transformer used in the locomotives built by his firm for the trials above referred to. This transformer had to be placed under the car floor, no other place being available, and its three coils had to be placed side by side, having their long axis correspond with that of the car itself. In this way pipes could be placed within the cores through which cool air would circulate.—*Electrical World and Engineer*, October 19th, 1901, pp. 644, 645. (Ill.)

MARINE AND NAVAL ENGINEERING.

1. War Vessels.

Battleships.—*The Russian Battleship "Retvizan."* Description of what may be called the first important foreign battleship constructed in an American shipyard. The *Retvizan* is a first-class battleship of 12,700 tons displacement, and in size and speed may be compared with the United States vessels of the *Maine* class, and during her builders' trial, which she recently underwent, attained an average speed of 18·8 knots.—*Scientific American*, October 26th, p. 263. (Ill.)

2. Freight and Passenger Vessels.

Junks.—*The Chinese Junks.* Summary of a paper by Mr. Winterburn, managing director of the Victoria Foundry, Hong Kong, read at the opening meeting of the autumn session of the Institute of Marine Engineers. The author points out that the statement that the Chinese retained the same kind of ship they had some 3000 years ago is most likely correct. Equally true, he remarked, was the saying that the Chinese had anticipated many of our modern inventions and discoveries. Thus, on the West River might be seen the prototype of the turret ship, bearing an extraordinary resemblance to our North of England monstrosities; and if the gallant captain who a year or two ago discovered and published that perforated sails are more effective than any other kind were to visit the Yangtse, he would see more of that kind of sail than any other. In fact, many of what we call modern ideas in shipbuilding and management were anticipated by the Chinese, who seem to be by no means contemptible constructors of vessels.—*Steamship*, November, 1901, p. 169.

3. Pleasure Craft.

Yachting.—*Fifty Years of "America Cup" Contests.* This is a concise review of the various races that have taken place during the period mentioned, and of the yachts, English and American, that participated in the contests.—*Scientific American*, October 5th, 1901, pp. 217, 218. (Ill.)

4. Engines and Equipment.

Marine Engines.—*Richardson & Westgarth's Exhibit at the Glasgow Exhibition.* Description of the display of the firm above named, which is the largest marine engine building firm in the world, having an output of 100,000 h.p., and employing 3,500 men in their works at Hartlepool, Middlesbrough, and Sunderland alone. The most important exhibit referred to is a compound inverted direct-acting condensing engine of 600 i.h.p. (maximum), direct-coupled to a continuous-current dynamo of 300 kilo-watts.—*Steamship*, Oct., 1901, pp. 127, 128. (Ill.)

—— *Simpson, Strickland & Co.'s Exhibit at the Glasgow Exhibition.* The article deals with an interesting exhibit of the above-named firm, consisting of small steam engines and boilers comprising eight sets, ranging from the smallest size made up to a large set for fast launches. Of special interest is a Cross patent four-crank quadruple expansion engine, with a Thornycroft water-tube boiler alongside—shown arranged in the manner in which they are fitted in a launch.—*Steamship*, Oct., 1901, pp. 432-35. (Ill.)

Spring Buffers.—*"Vulcan" Patent Spring Buffers for Steering-Gear Chains.* Description of improved patent spring buffers to relieve the gear-chains from the frequent shocks on the rudder. These patent spring buffers consist of a square section steel spiral spring, which works upon a large socket made to fit the inside diameter of the

spring, insuring that it is central and alignable, and effectively prevents buckling. By various ingenious contrivances the buffer and tightening screw render it unnecessary to fit tightening screws on each side of the gearing-chains. Moreover, the new spring buffers take less room than other types, and the thread of the screw is properly protected.—*Steamship*, Nov., 1901, p. 177. (Ill.)

5. Miscellaneous.

Marine Engineering.—*Review of Marine Engineering during the last ten years.* Under this heading is published a digest of a paper read by Mr. James M'Kechnie, of Barrow-in-Furness at the summer meeting of the Institution of Mechanical Engineers, held at Barrow-in-Furness, August, 1901. This paper is one of those that are read at the beginning of each decade, reviewing the progress made in marine engineering during the previous ten years.—*Steamship*, Oct., 1901, pp. 135-40. (Ill.)

Power Supply in Shipyards and Marine Engine Works.—*Notes for Discussion on Electrical Power Supply in Shipbuilding Yards and Marine Engine Works.* This is an abstract of a paper read by Robert Robertson, B.Sc., at the Glasgow International Engineering Congress, in which the author dwells on the advantage of using electricity as the source of power in engine works, which he summarises as constituting (1) a saving in cost of power, (2) as giving to the power output and transmission great flexibility, and (3) as resulting in an increased output. In shipyards, he claims, these advantages are still enhanced, as there the benefits obtained from flexibility reach their maximum, and to this must be added the great facility with which electricity may be applied to all forms of gantries, cranes, etc.—*Steamship*, Nov., 1901, p. 166.

Signalling.—*Foster's Fog Signals.* Description of a signalling apparatus, consisting in the main of an automatically revolving megaphone which concentrates and projects various signals first in one direction and then in another, combined with a device for varying the signal according to the direction from which the sound is sent. A vessel passing must hear one of these sounds more clearly than any other, and this indicates to it the exact direction from which the sound comes. Experiments made by the Lighthouse Board of the United States have demonstrated that when a vessel is opposite to one of the megaphone trumpets the sound sent out by this is overpoweringly greater than that emitted by any of the others, and that at a distance of more than a mile it is impossible to hear the sound of any of the trumpets except the one that is right opposite to the listener.—*Scientific American*, Sept. 28th, 1901, p. 200. (Ill.)

MECHANICAL ENGINEERING.

1. Boilers, Furnaces and Fuel.

Boiler Economy.—*The Working Economy of the Steam Boiler.* By Charles Arthur Hague. The author dwells on the disagreement between expert tests and the results given under service conditions. He does not criticise, as the editor remarks, "expert tests" *per se*, but points out that the results of such test should be taken as a standard for comparison rather than as a standard of daily performance. To render the comparative performance standard conditions ought to be made as perfect as possible, and all uncertain factors should be eliminated. This may not be an economical procedure under ordinary circumstances, but the data so obtained form a basis for judging work from day to day, and for comparing it with other installations.—*Engineering Magazine*, October, 1901, pp. 91-100.

Boiler Efficiency.—*On Some Attempts to Increase the Efficiency of Marine Boilers.* By G. M. Brown, B.A. (Cant.), B.Sc.(Dun.), Wh.Sch. A paper read before the North-East Coast Institution of Engineers and Shipbuilders. The author points out that he does not desire to criticise existing systems of forced and induced draught, but rather to draw attention to some proposed improvements, in the hope of provoking discussion.—*Transactions of the North-East Coast Institution of Engineers and Shipbuilders*, March, 1901, pp. 99-111. (Ill.) Discussion l.c., May, 1901, pp. 115-28; Mr. Brown, reply, July, 1901, pp. 197-200.

Boilers.—*Water-Tube Boilers.* By Edwin Griffith, Wh.Sch. A paper in which the author directs attention to the present position of water-tube boilers from the marine engineer's point of view, and emphasises his remarks on some of the defects of this type of boiler. Though written before the report of the Admiralty Committee of Inquiry, the contents of the paper agree at all essential points with the finding of the Committee.—*Transactions of the North-East Coast Institution of Engineers and Shipbuilders*, May, 1901, pp. 157-81. Discussion l.c., pp. 181-93, and July, pp. 201-15.

2. Compressed Air.

Air Compressors.—*Hydraulic Compression of Air.* By Wm. O. Webber. The author, after a short historical introduction, describes the patents issued to Mr. J. P. Frizell, of Boston, Mass., and the later patents granted to Mr. Charles H. Taylor in 1895. The first compressors on the Taylor principle were installed at Magog, Quebec, to furnish power for the print works of the Dominion Cotton Mills Company. The concluding portion of the article is devoted to a short account of three plants now under construction, one at Peterborough, Ontario, one at Norwich, Conn., and one in the Cascade Range, State of Washington.—*Power*, Oct. 1901, pp. 3, 4. (Ill.)

3. Engines and Motors.

Automotors.—*The Wolseley 10-h.p. Motor Cars.* Description of this auto-motor, built by the Wolseley Tool and Motor Car Company, Birmingham, which was awarded a gold medal by the judges in the Glasgow trials, while the 6-h.p. car built by the same company received the same award for their all-round excellence. These cars represent, as the author remarks, very high engineering skill, are designed on the liberal lines that the great French races have proved to be most advantageous in motor cars, in addition to English scrupulous regard for details and finish.—*Automotor Journal*, Oct. 1901, pp. 6, 7. (Ill.)

—— *The Yorkshire Steam Motor Wagon.* Account of the main features of the Yorkshire Steam Motor Company's steam motor wagon, the most striking peculiarities of which appear to be the construction of the boiler, the arrangement of the gearing, and the manner in which the cylinders are mounted.—*Automotor Journal*, Oct. 1901, pp. 10, 11. (Ill.)

Fans.—*A Remarkable Advance in Air-propelling Machinery.* Davidson's *Patent "Sirocco" Centrifugal Fans.* Description of a type of fan in which the blades are very numerous, with their radial measurement, relatively to the diameter of the fan, very shallow, and their axial measurement very long, their outer edges being curved in the direction of quotation, and the air-passages between the blades usually open at the ends towards the inflowing air. During a comparative test between a "Sirocco" Fan and a "Centrifugal" Blown Fan the amount of air discharged, given in cubic feet per minute, amounted, according to the author of the article, to 16,320 for the "Sirocco" type, against 3,250 for the competing fan, although the former had a diameter of 12½ ins. only, while the latter's diameter was 24 ins. The makers are Messrs. Davidson & Co., Belfast, with Branches in London, Manchester, and Glasgow.—*Machinery Market*, Oct. 3rd, pp. 385-7. (Ill.)

Gas Engines.—*Blast Furnace Engines at Differdingen.* Short paragraph describing a photo-engraving, showing the interior of the central electric and blowing engine of the large iron and steel works in Luxembourg above named. The illustration gives a good idea of the size of the powerful engines, of which there are three of 600 h.p. each direct-coupled with a dynamo, and also six of 600 h.p. coupled to six blowing cylinders, for providing air for the furnaces of half the atmospheric pressure.—*Engineer*, Oct. 4th, p. 352. (Ill.)

4. Power and Transmission.

Hydraulic Elevators.—*Electrically-controlled Elevators.* By Wm. Baxter, Jun. Certain classes of elevator—such, for instance, as are used in private houses—require

an arrangement by which they can be worked from any floor, and brought up or drawn down, not only from the inside, but also from the cutside, as in most cases there is no attendant; and the same can hold good of elevators worked as dumb waiters. This can best be accomplished by means of electro-magnets and suitable circuit connections between them, and push-buttons in the car and at the various landings. The Otis Elevator Company in the United States makes use of various devices of this kind, some of them to be worked by the incandescent light circuit, others using current from primary batteries. An arrangement of the former kind forms the subject of the article here referred to.—*American Machinist*, Sept. 28th. 1901, pp. 1031-2. (Ill.)

5. Machine Works and Foundry.

Foundries.—*Plant of the Interstate Foundry Company, Cleveland, Ohio.* Concise description of a well-equipped modern foundry, the output of which is almost entirely restricted to comparatively light castings. The total floor-space of the foundry proper covers 42,000 sq. ft., all in one room, the only obstructions being two rows of columns supporting the roof. Another foundry of equal size, to be devoted to machinery castings and heavy work in general, is to be erected later on. Careful provision has been made for heating and ventilation.—*Foundry*, October, pp. 51, 52. (Ill.)

Locomotive Works.—*Swindon Locomotive Works.* Under this heading Mr. G. A. Sekon gives an interesting account of the famous locomotive works of the Great Western Railway, founded in 1840, when where they are now situated there were but "green fields," and the town of Swindon was some two miles distant. A portion of the engine-house was in use as early as 1842, and the original works were completed in 1846. Since then they have been gradually expanding to their present size; and this evolution, together with their modern equipment, form the chief contents of the article.—*Railway Magazine*, October, 1901, pp. 290-304. (Ill.)

Notable Industrial Establishments. — *Messrs. Clarke, Chapman & Co., Ltd., Gateshead-on-Tyne.* The article deals with the works of this important engineering firm, which have been gradually but constantly expanding ever since their foundation in 1864, until at present they employ an average of about 2,000 hands. The author of this contribution begins with a reference to the firm's leading specialities, such as steam-winding, hoisting, and hauling engines, windlasses, capstans, steam boilers, pumps, and electric apparatus. These are further dealt with in a somewhat full account of the exhibits of the firm at the Glasgow Exhibition; and in a third section, the more important details and peculiarities of the firm's specialities are described. A fourth section is devoted to an account of the works and their equipment, the foundry, the forge, and stamping department, the boiler shops, the electrical department, the pump department, and the offices. The article concludes with a few historical data and personal references.—*Machinery Market*, Sept. 5th, 1901, pp. 325-45. (Ill.)

Notable Industrial Establishments.—*The Works and Productions of Messrs. G. & J. Weir, Ltd., Cathcart, N.B.* Under this heading is given an article describing the situation of the works and arrangement of the offices, and the development of the business of this well-known Scottish engineering firm, together with a special account of the works, laid out on the most modern lines: the cylinder and pump boring department, the screwing department, the generation and transmission of the motive power, the stores, the fitting department, the tool room, the erecting shop, the pattern-making shop, the foundries, the steam power house, etc. The next section of the article is devoted to the productions of the firm, *i.e.*, their marine feed-water heaters, feed pumps, general service pumps, the "Weir" differential pump, high-pressure feed pumps, evaporators, the "Weir hydrokineter," the independent air pumps, and the "Weir" water-tube boiler. The concluding portion deals with the general organisation and management of the works, the application of the premium system, and Messrs. Weir's Glasgow exhibit.—*Machinery Market*, Oct. 3rd, 1901, pp. 375-84. (Ill.)

Steel Castings.—*Annealing of Steel Castings.* Cast steel has by no means fulfilled all the expectations to which its discovery gave rise, as is shown, among other things, by the fact that the U.S. Government is going back to the old-fashioned wrought-iron anchors for its ironclads, in view of the treacherous and mysterious failures of even the very best types. Mr. W. M. Carr, chief chemist for the Schickle, Harrison and Howard Iron Co., St. Louis, Mo., U.S.A., having been induced to take up the study of cast steel by the microscope, believes it to be of inestimable value as an adjunct to an ironworks laboratory. Under the heading above given he publishes some of the results of his studies, and arrives at the conclusion that brittleness in finished castings is due to a degree of crystallisation due to imperfect heat treatment. The nearer cast steel approaches a non-crystalline or distinctly amorphous structure, the less will be the degree of brittleness, or, conversely, the greater will be the degree of toughness. For this reason, he argues, it becomes necessary to anneal all ordinary steel castings, by which is not meant that continued heating at a white heat usually called annealing, but a heat treatment by which crystallisation or brittleness of the steel is removed, the degree of heat varying with the carbon contents and the length of time with the size of the piece. With adequate attention to chemical composition and subsequent heat treatment, he argues, steel castings can be made that, with a strain not exceeding the elastic limit, will have practically an indefinite life.—*Foundry*, Oct., 1901, pp. 59, 60.

6. Machine Tools.

Machine Tools.—*The Tooling of Machine Tools.* The author of the serial contribution under the above heading, Mr. John Ashford, M.Inst.Mech.E., dwells on the fact that though much has been written on machine tools, very little has been said on using them. When the machine tools are set to work by men who never had seen anything like them, and do not turn out the amount of work stated by the maker, the company directors grumble and blame the latter. So, also, instead of treating the new machine in the best possible manner, they lubricate it with trickle of suds from a drip-can, instead of using a proper pump, which would cost from £4 to £5, and refuse to countenance the purchase of lard-oil on account of its higher cost, and substitute cheap stuff, which, of course, prevents the machine from properly working. After criticising this new illustration of being "penny wise and pound foolish," the author of the contribution proceeds to describe the proper way of tooling and arranging various machine tools shown at the Glasgow Exhibition.—*Engineering*, Oct. 11th, 1901, pp. 505-7; Oct. 18th, pp. 539-42. (Ill.)

BOOKS RECEIVED.

The *Practical Engineer* Pocket Book and Diary: price 1/- nett, leather, gilt, with Diary on ruled section; paper, 1/6 nett; postage, 2*d.* extra.

The *Practical Engineer* Electrical Pocket Book, 1902, price 1/6 nett; without Diary, 1/- nett; postage 2*d.* extra.: The Technical Publishing Company, Ld., 31, Whitworth Street, Manchester.

Shepardson's Catechism: published by *The American Electrician*, price $2.

Practical Electric Railway Handbook, by Albert B. Herrick: The Street Railway Publishing Co., 120, Liberty Street, New York, price $3.

Metal Working Tools and Their Uses (The Model Engineer Series, No. 7), by Percival Marshall, A.I.M.E.: Dawbarn & Ward, Ltd., 6, Farringdon Avenue, London, E.C., 6*d.*

The American Invaders, by Fred A. McKenzie: Howard Wilford Bell, Hastings House, Norfolk Street, Strand, W.C., 6*d.*

Water Tube Boilers, by Leslie S. Robertson, M.Inst.C.E., M.I.Mech.E., M.I.N.A.: London, John Murray, Albemarle Street, W., 8/- nett.

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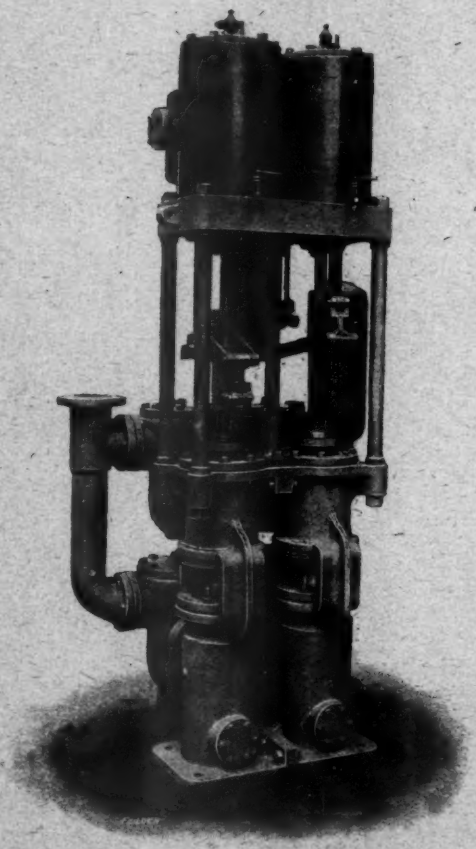

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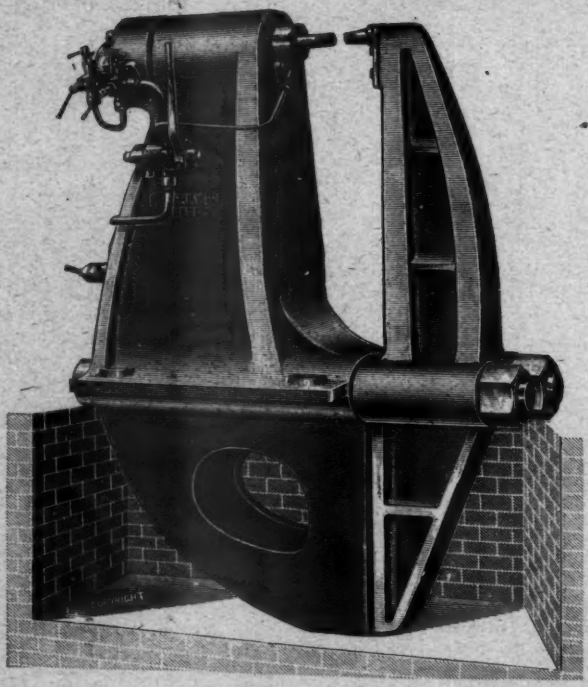

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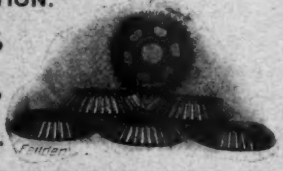

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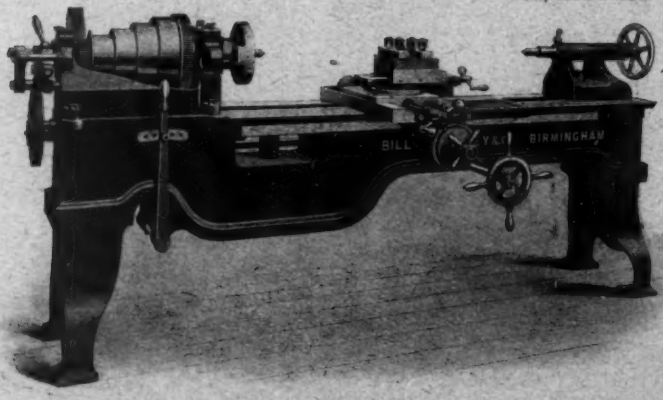

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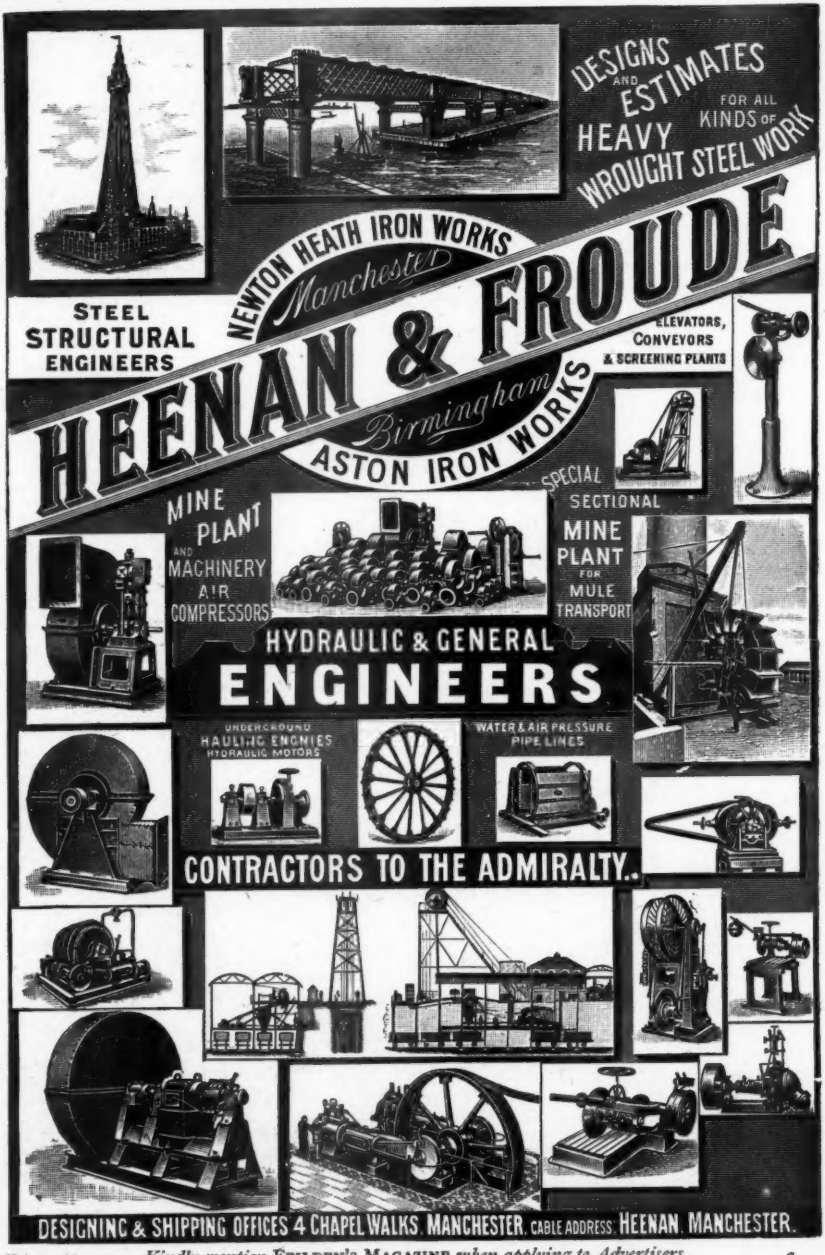
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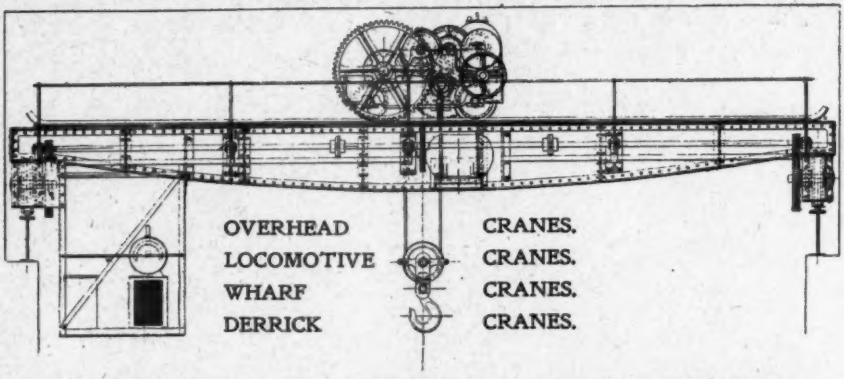

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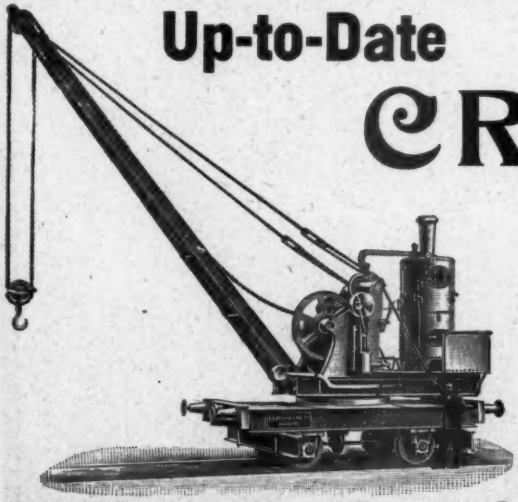

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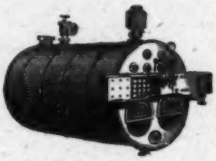

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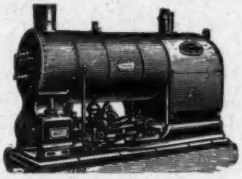

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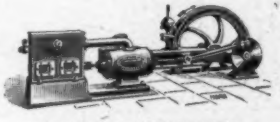

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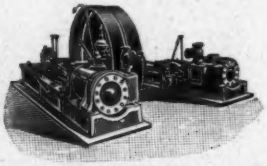

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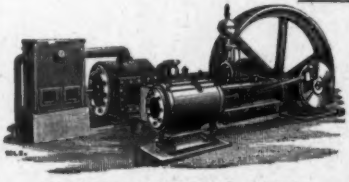

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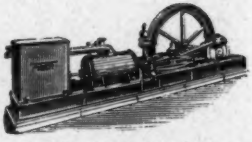

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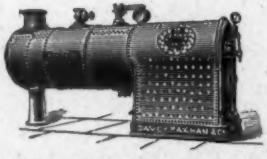

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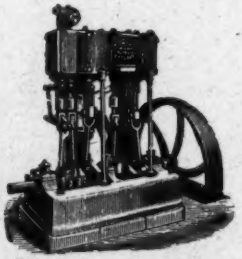

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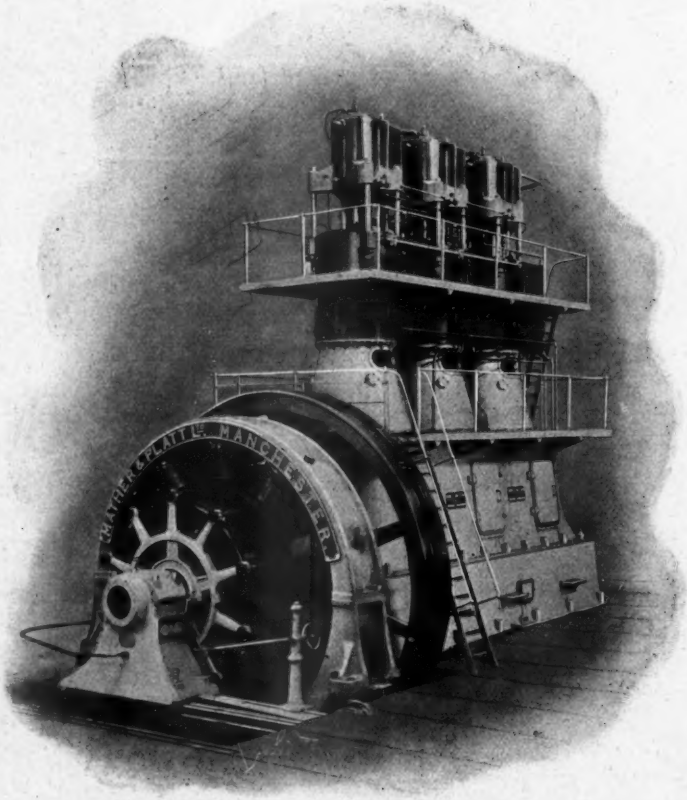

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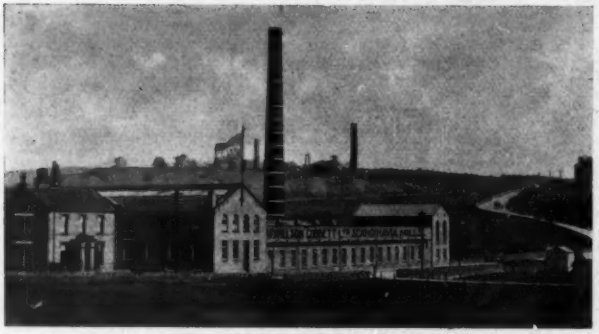

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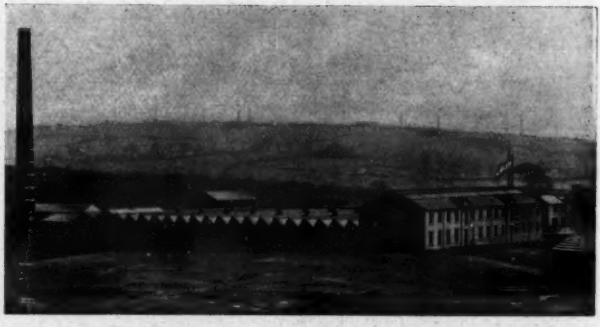

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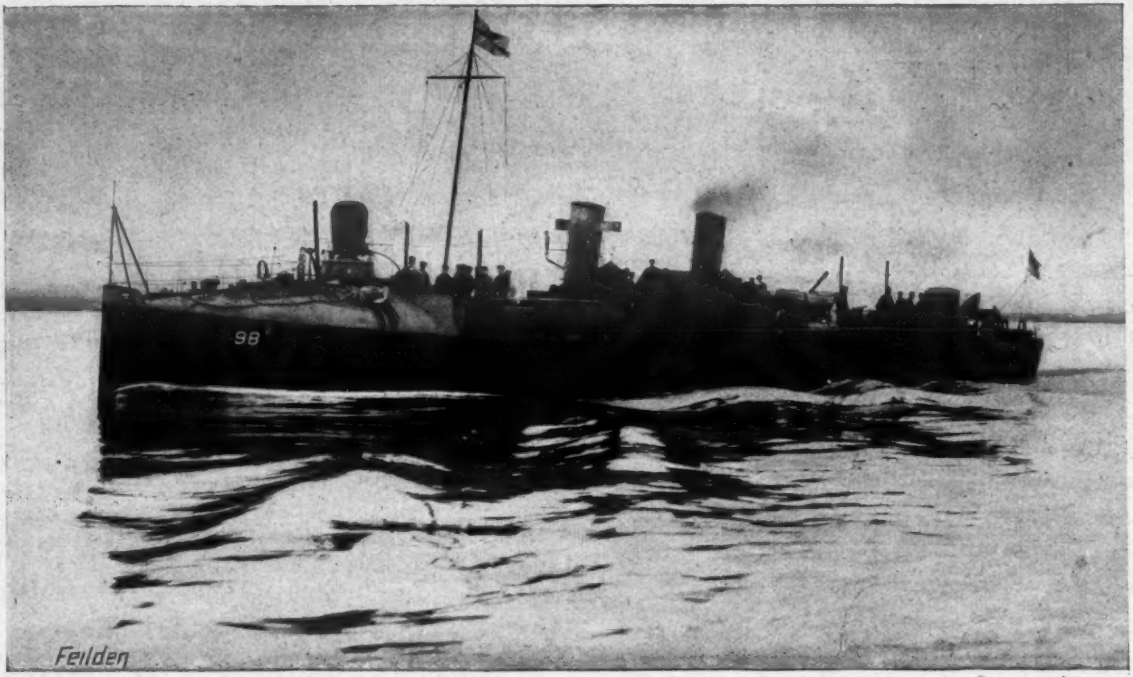

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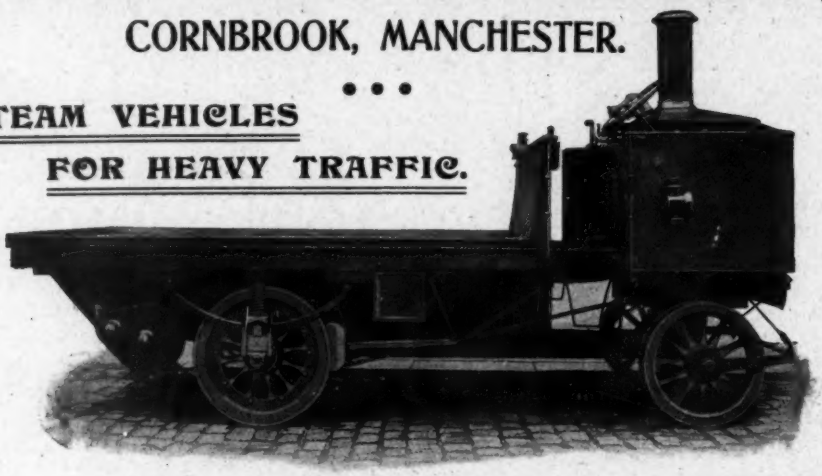

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WE WILL FIT UP ONE FLUE OF YOUR BOILER

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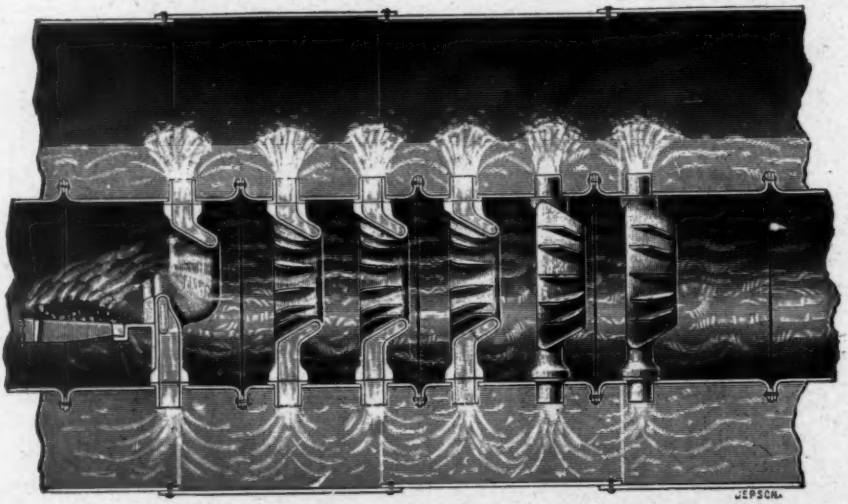

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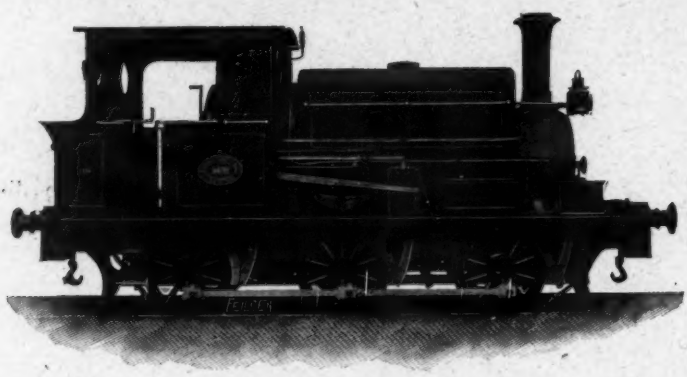

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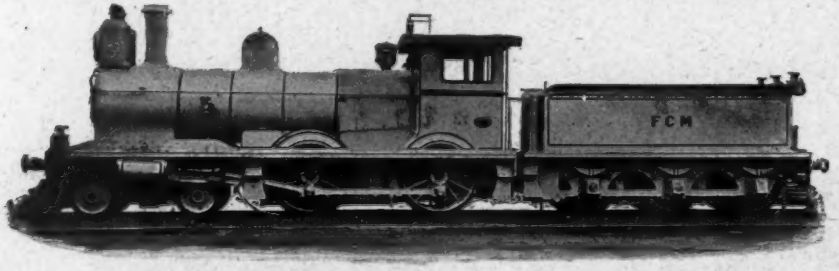

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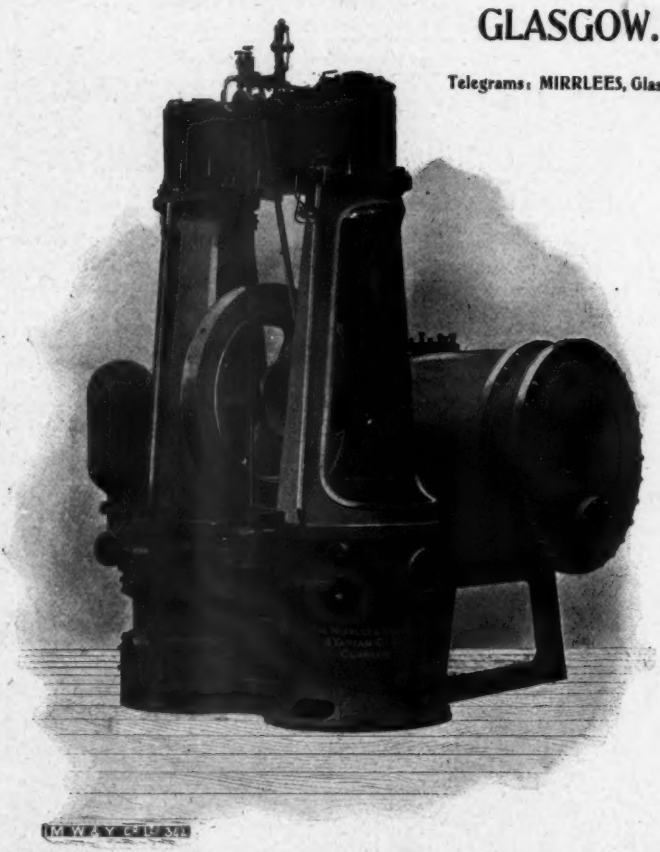

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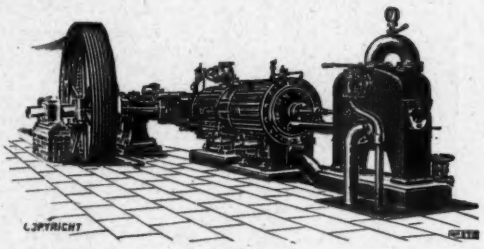

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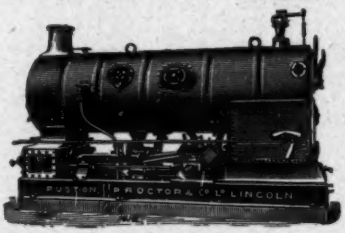

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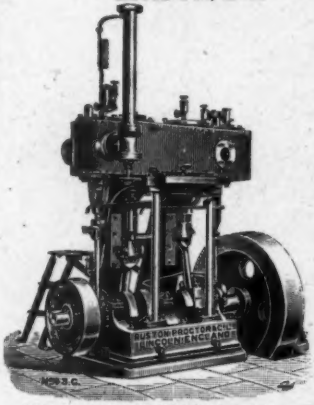

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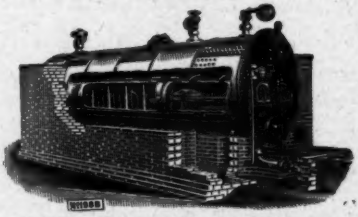

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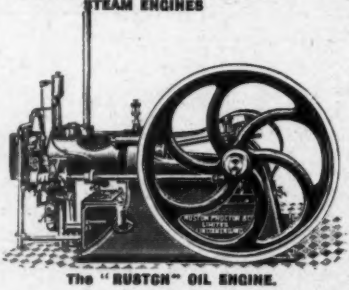
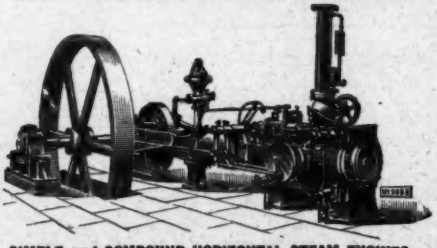


The "RUSTON" OIL ENGINE.



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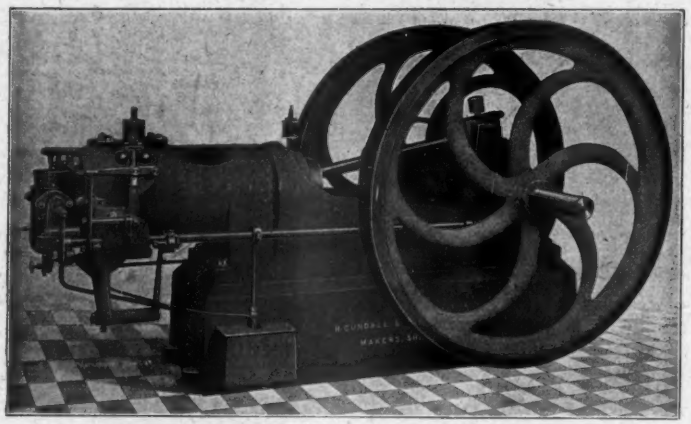

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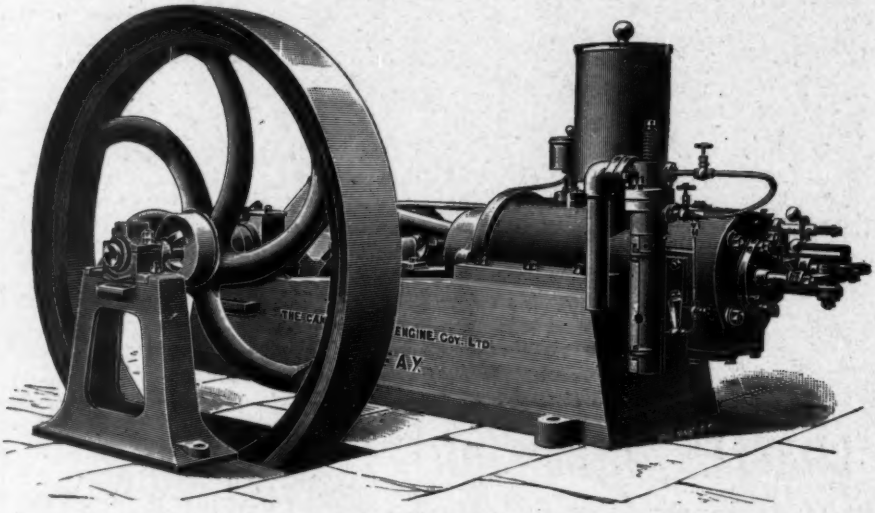

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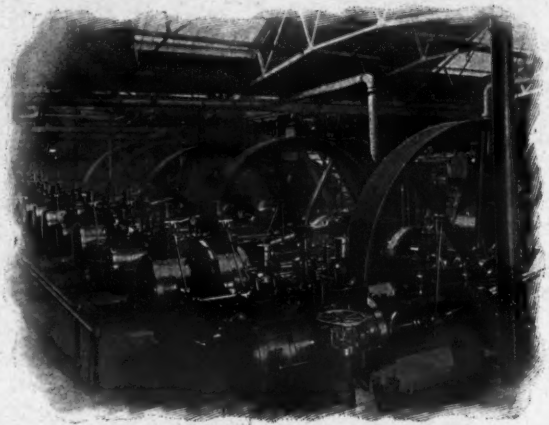
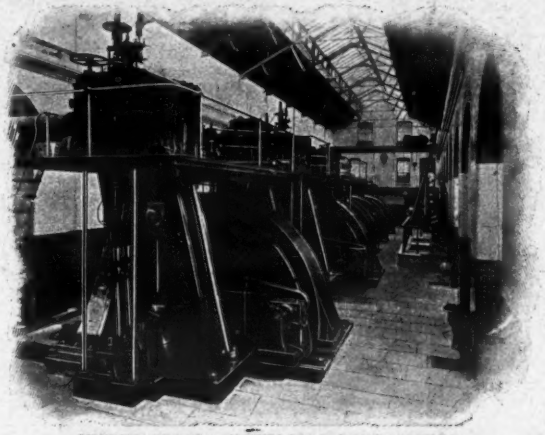


COUPLED COMPOUND HORIZONTAL FIXED ENGINES.



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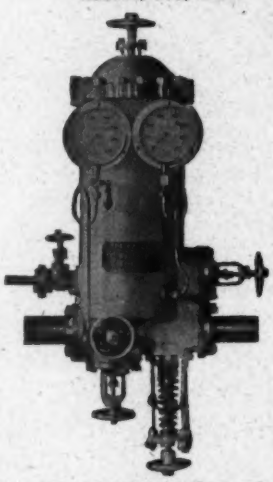

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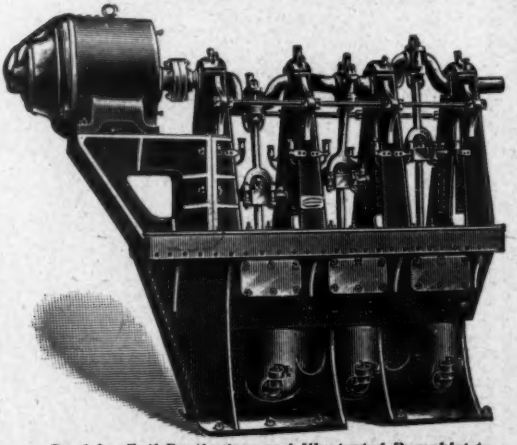

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MAINTENANCE CHARGES REDUCED TO A MINIMUM.

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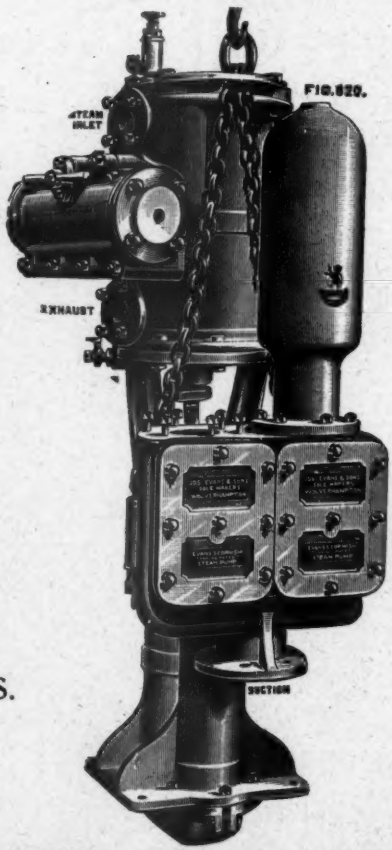

FIG. 820.

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NO TAPPETS,
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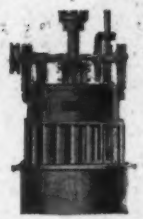
(McCormick's Patent)



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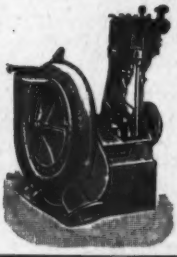

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JOHNSON'S PATENTS.

SECTION OF "DRUM" PUMP.

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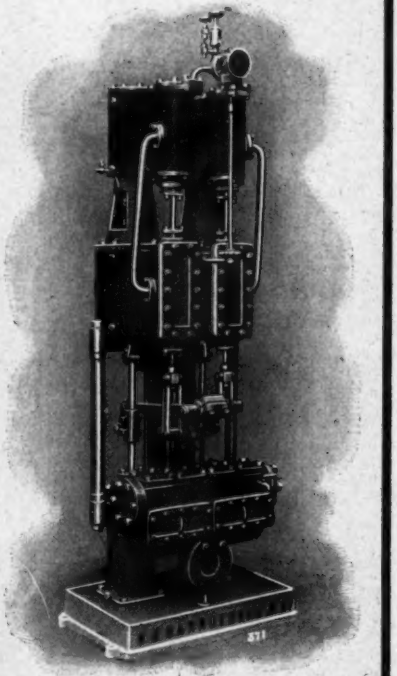

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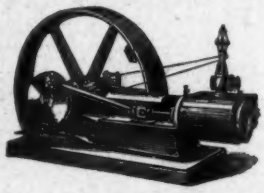
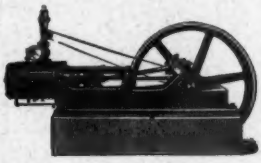
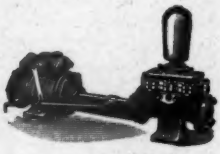


ENGINES, BOILERS and PUMPS





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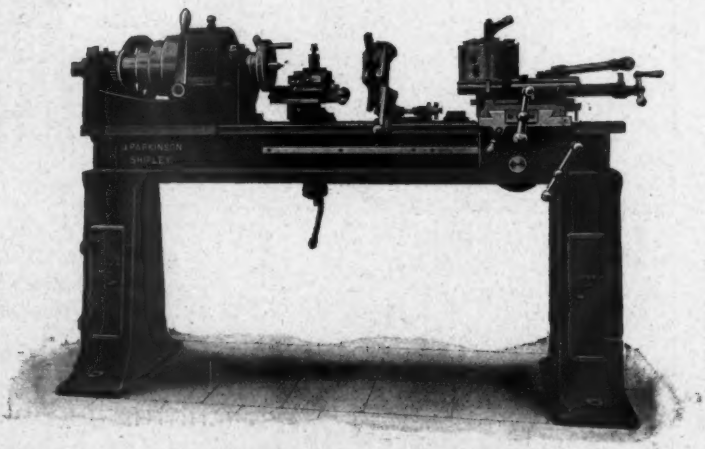

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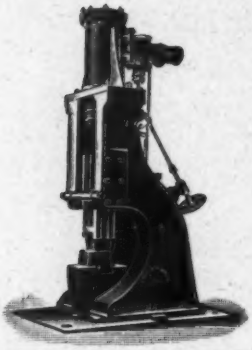

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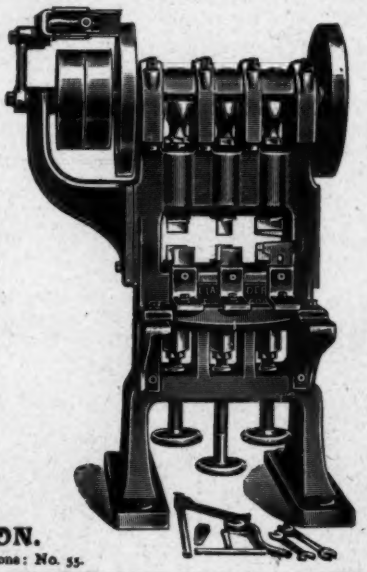

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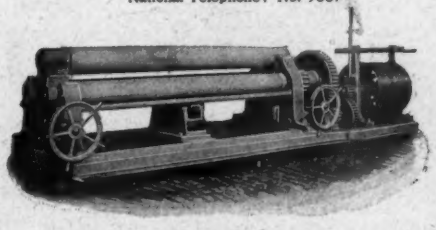

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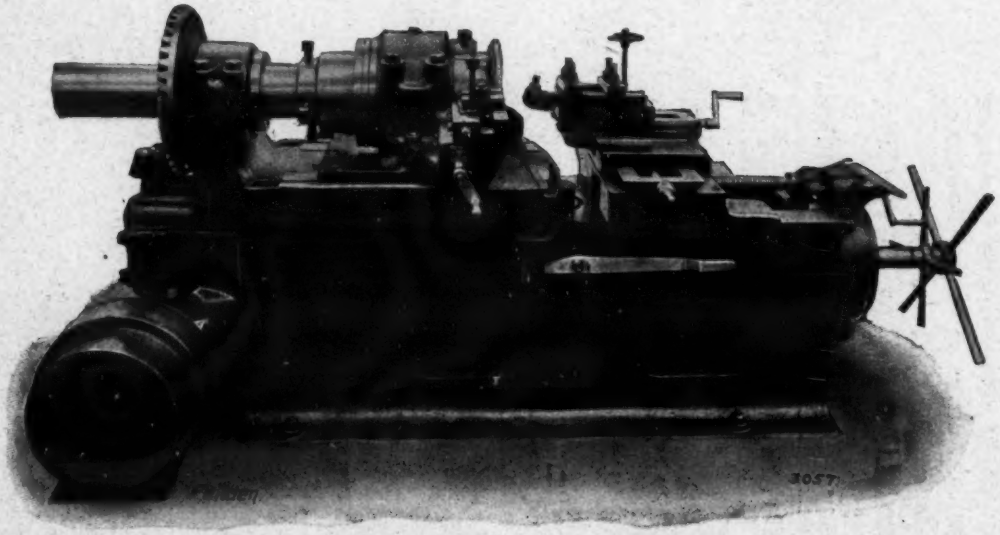

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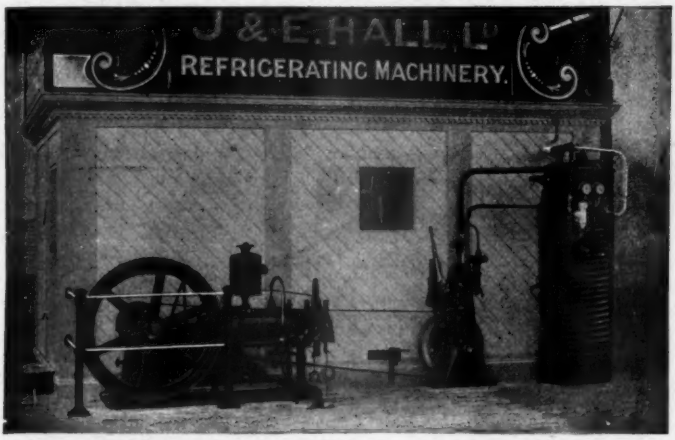

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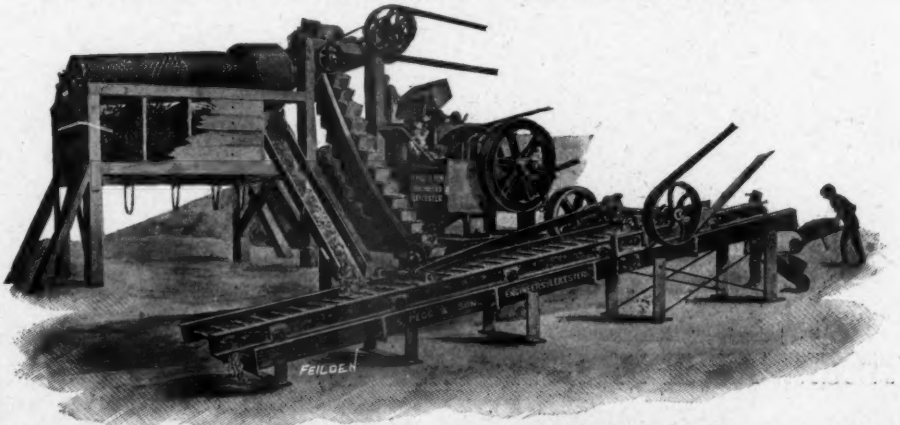

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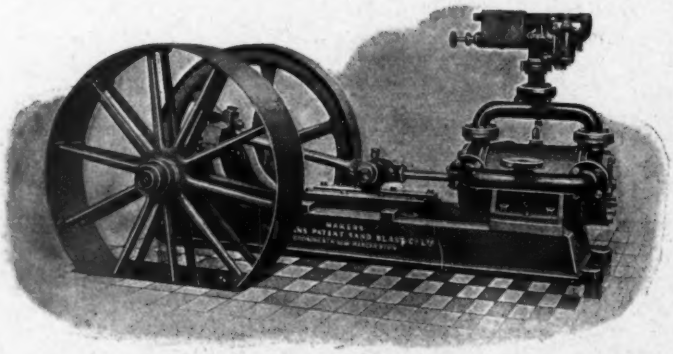

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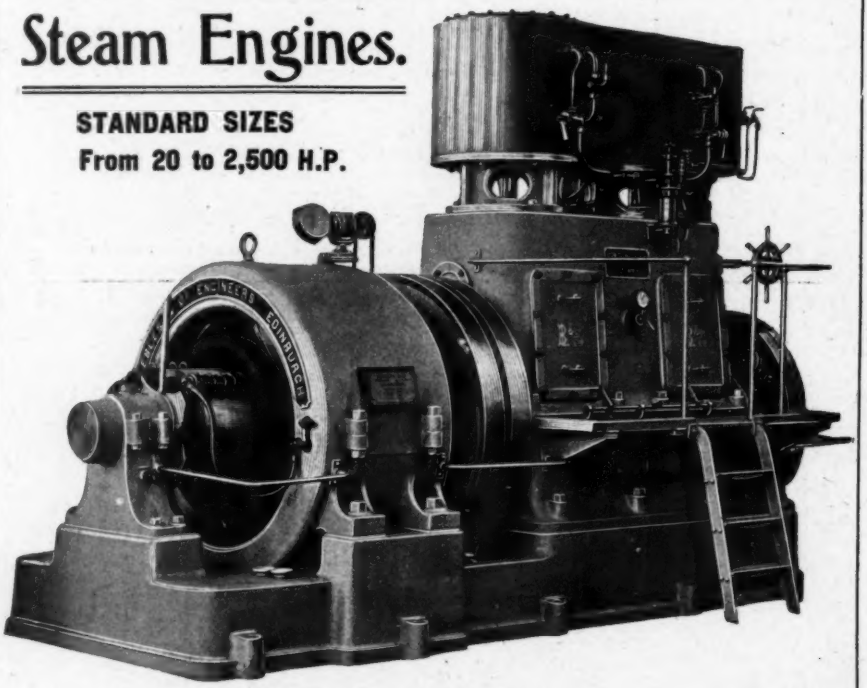

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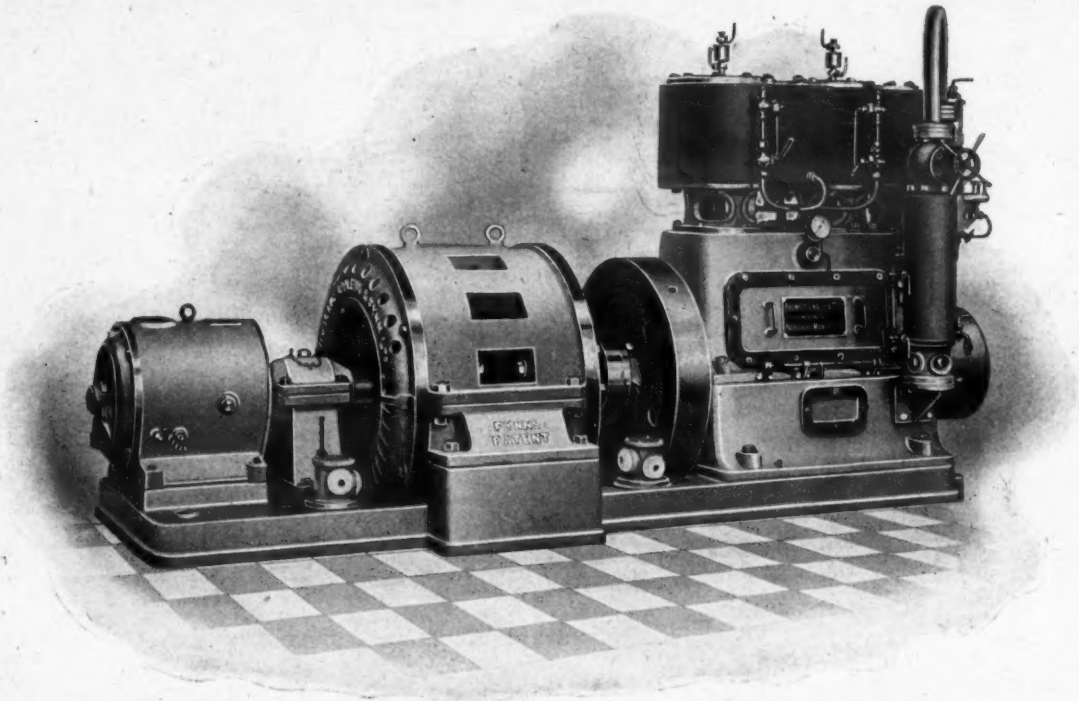

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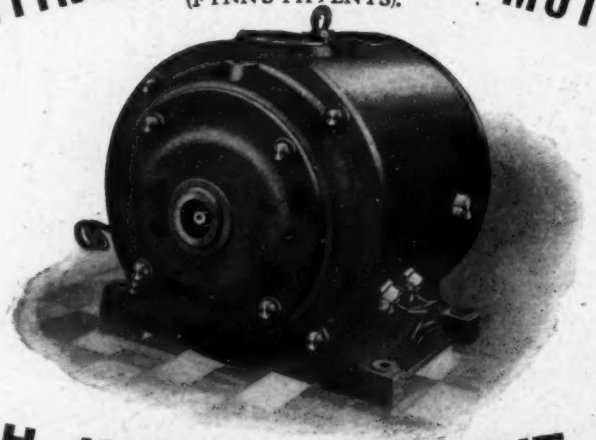

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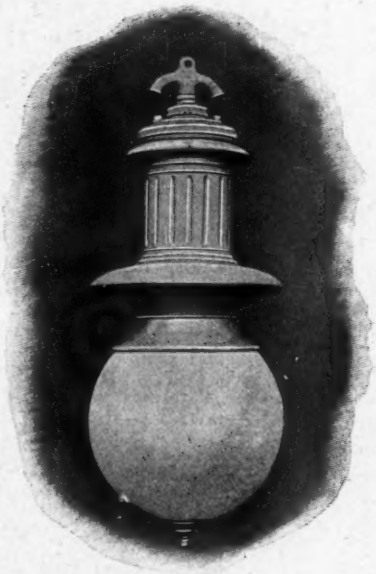

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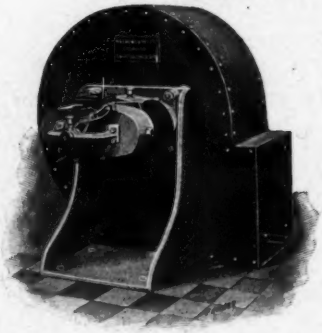

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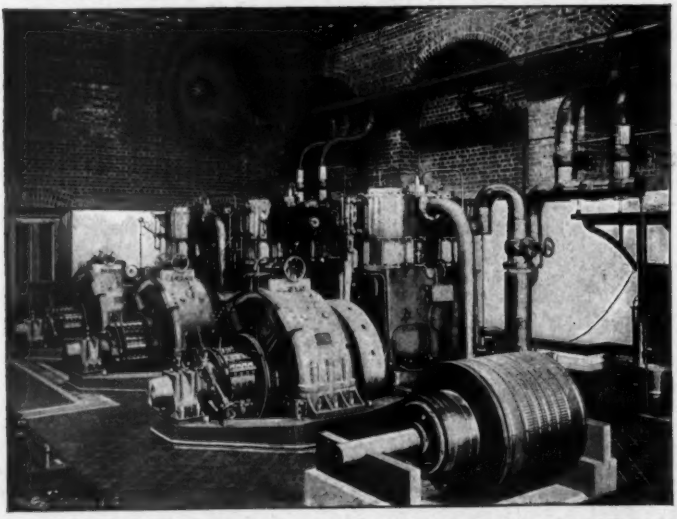

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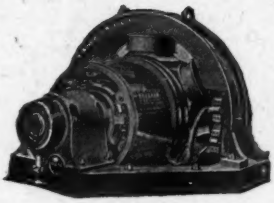

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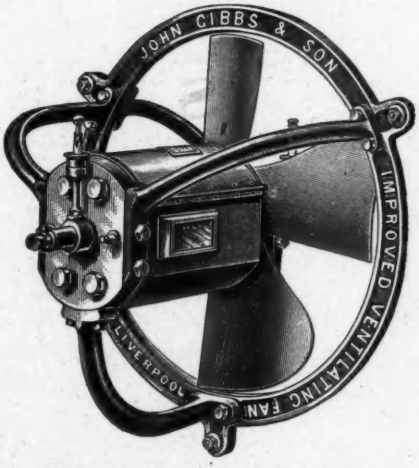

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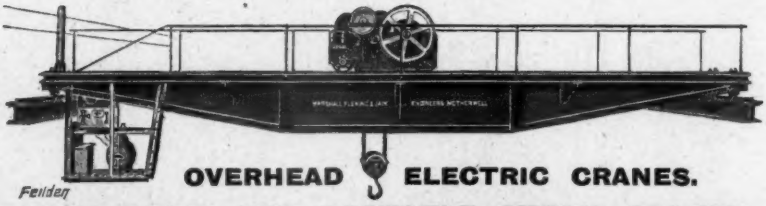

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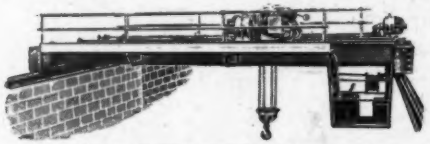

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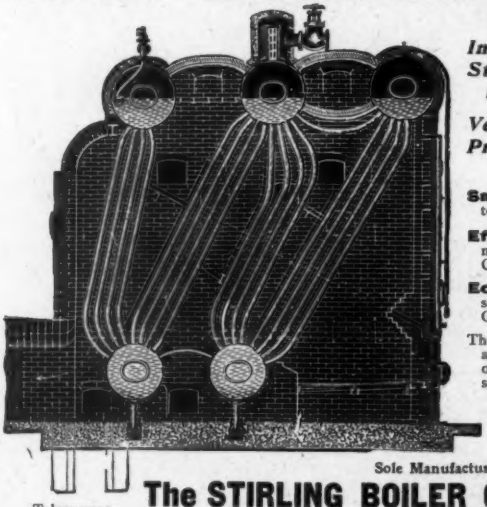

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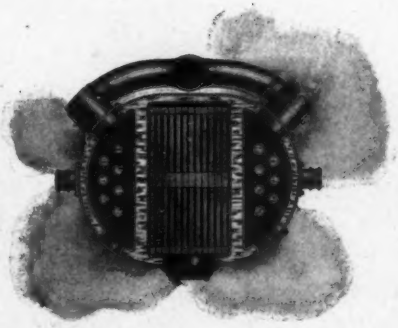

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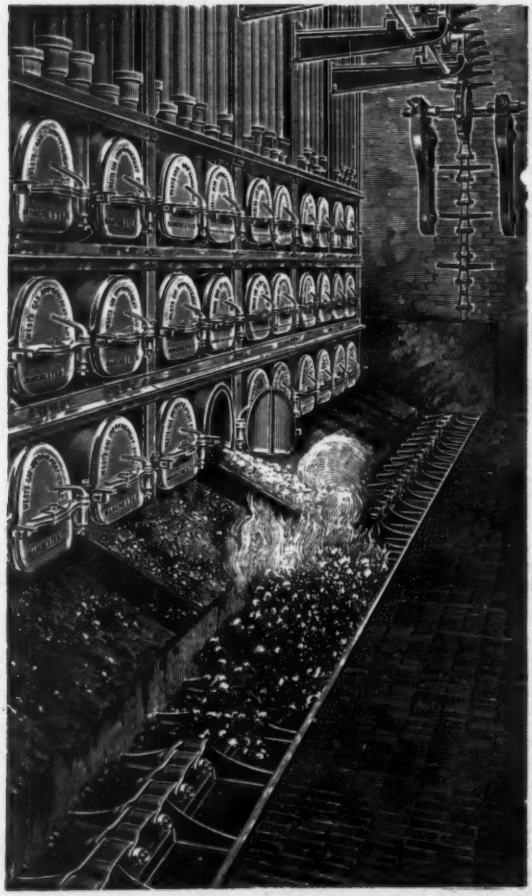

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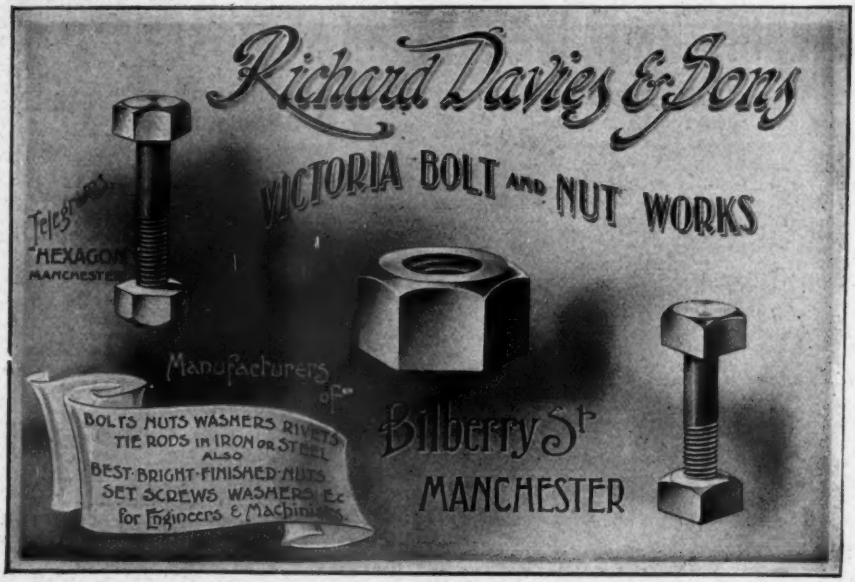
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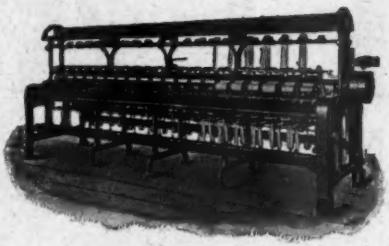

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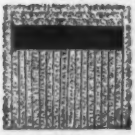

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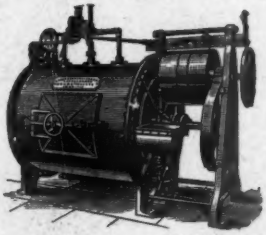

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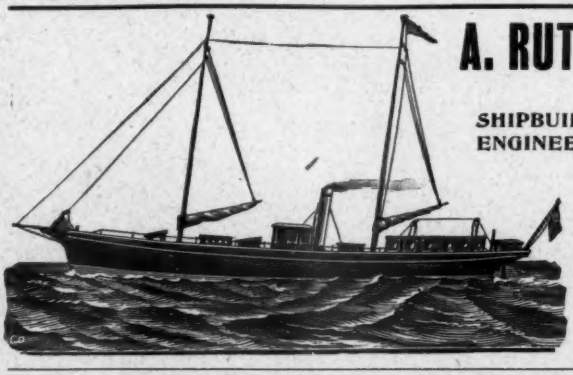

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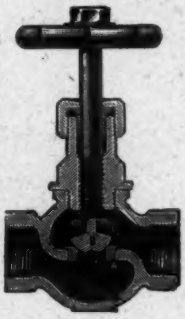

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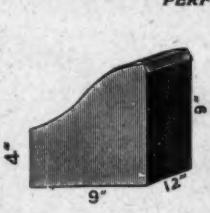

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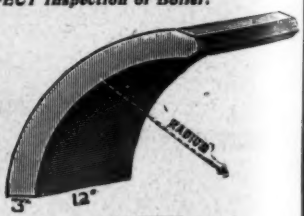

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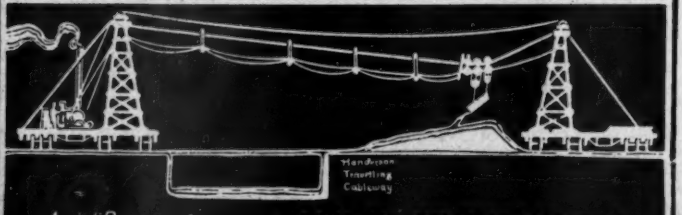

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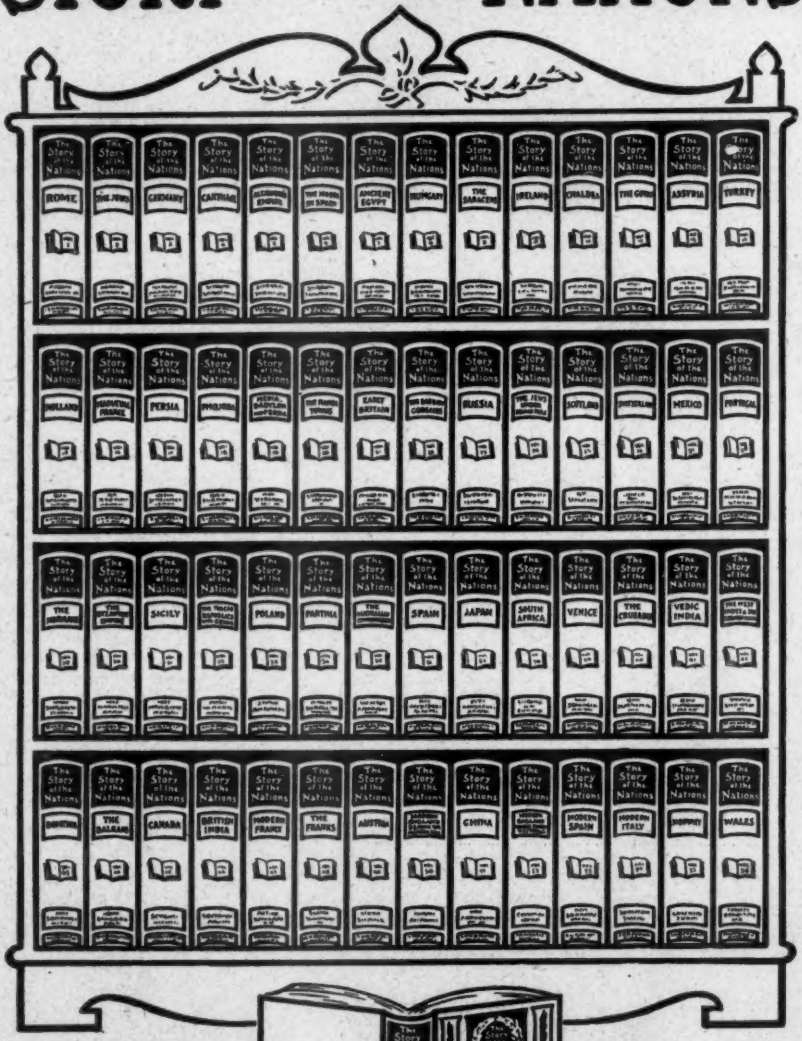

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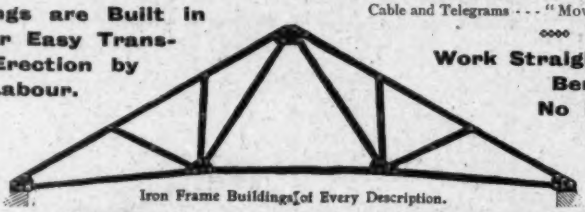

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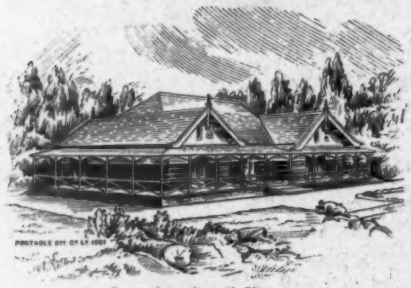

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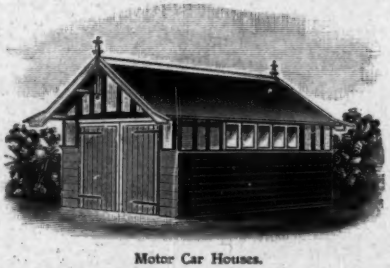

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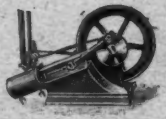

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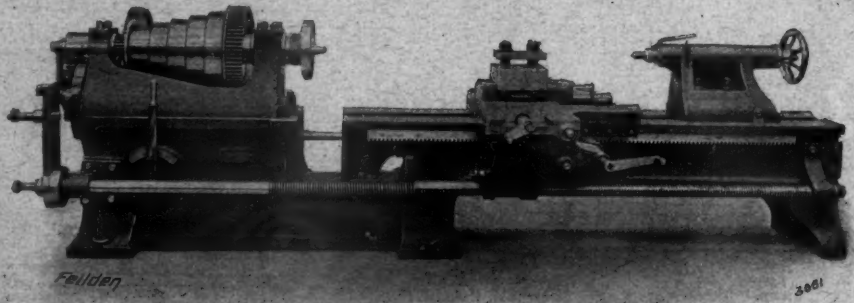

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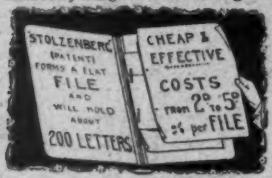

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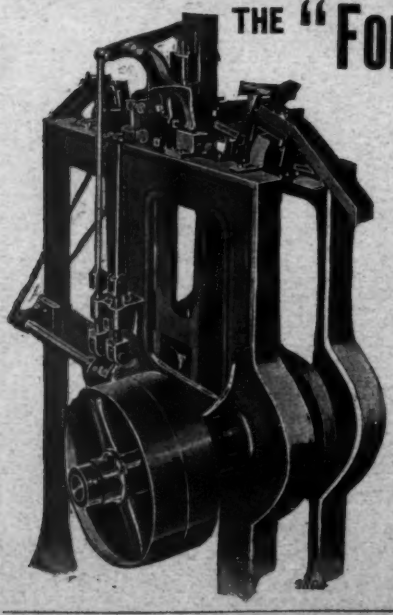

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